APPRAISAL OF RURAL AND URBAN LAND USES SUITABILITY IN WETLAND CONSERVATION: A CASE OF ONDIRI SWAMP, KIKUYU SUB-COUNTY

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DECLARATION

I hereby declare that this thesis is my original work and has not been presented or submitted for examination in any other University.

Sign: ..... Date: 12th April 2024

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This thesis has been submitted for examination with my approval as the research supervisor.

Sign: ..... Date: 12th April 2024

Prof. Isaac K. Mwangi

ABSTRACT

Wetlands are regions where water have existence on or near the earth's surface, covering the soil completely. The environmental amenities that wetlands offer to immediate communities and distant users, as well as tangible and intangible economic and ecological values regionally and even globally, are immense. However, they are now at risk as they have been endangered by agriculture, invasive species, developments in housing, agricultural run-offs, wastewater affluence, and stormwater. These threats cause changes within the fragile environmental ecosystem.

The study's ultimate goal was to evaluate the effects of rural and urban land use on wetlands, namely the Ondiri Swamp in Kikuyu, Kenya. The study focused on rural land use activities in the Ondiri Swamp community and urban land use activities in Kikuyu town, both of which have an impact on the wetland's ecological functions. The study also evaluated, ranked, and prioritized the elements that influence rural and urban land use activities, forming the basis for intervention proposals.

The study employed a descriptive research design that incorporated both quantitative and qualitative methods in a mixed strategy. Archival approach was employed to collect secondary data. The original data was constructed using household and key informant questionnaires. The process of content analysis was employed to extract theme categories from source datasets. Remote sensing and geographical information system (GIS) analysis were employed to evaluate the spatial extent, morphological characteristics, and different forms of encroachment on the wetland.

Results of the data analysis, especially the land use land cover analysis, show that the increased population in the study area practices intensive agricultural activities. Built-up areas have also shown an increasing trend which is a result of an increase in residential areas, commercial activities, education centres, and industries. The study found that the land used adjoining the wetland affected the wetland negatively by introducing pollutants and abstracting water uncontrollably from the natural resource.

The study also established that one of the factors contributing to the negative rural and urban land use activities affecting the wetland is the overexploitation of natural resources. Besides that, the study also found that there were uncoordinated stakeholder efforts both from the state and non-state organizations and that has led to a lack of clear and common vision to guide and protect the wetland. The study concludes that research has not informed the planning and utilization of water, land, and vegetation resources at the Ondiri Swamp. Also, the presence of weak institutional capacity and weak law enforcement contributes to its continued ecological degradation.

This study, therefore, recommends strategies and land use planning interventions to arrest and reverse this trend toward environmental recovery and restoration.

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Finally, l would like to thank the management of the National Environment and Management Authority (NEMA) for inviting me to a stakeholder consultation meeting organized to develop the Ondiri Wetland Management Plan (OWMP). The stakeholders were mainly the institutions responsible for the management of the resource, professionals, experts, the community, and land users around Ondiri Swamp.

DEDICATION

This study is wholeheartedly dedicated to five people. The first two are my father Mr. Patrick W. Karanja and my mother Mrs. Hannah W. Wainaina, to whom l am forever indebted to their parental love, care, and support. The other three are my siblings: George Wainaina, Pauline Wainaina, and Samuel Wainaina for the fond memories of being brought up by our dear parents.

TABLE OF CONTENTS

DECLARATION i

ABSTRACT ii

ACKNOWLEDGMENTS iii

DEDICATION iv

TABLE OF CONTENTS v

LIST OF FIGURES xi

LIST OF TABLES xii

LIST OF PLATES xiii

ACRONYMS xiv

CHAPTER ONE: INTRODUCTION 1

1.1 Introduction 1

1.2 Statement of the Research Problem 2

1.3 Research Questions 3

1.4 Research Objectives 3

1.4.1 Overall Objective 4

1.4.2 Specific Objective 4

1.5 Assumptions of the Study 4

1.6 Justification of the study 4

1.7 Significance of Study 5

1.8 Scope of the Study 5

1.8.1 Geographical Scope of the Study 5

1.8.2 Theoretical Scope of the Study 7

1.9 Key Terms 7

1.10 Organization of the Study 7

CHAPTER TWO: RESEARCH METHODOLOGY 8

2.0 Introduction 8
2.1 Research Design 8
2.2 Target Population 8
2.3 Sample Size and Sampling Plan 8
2.4 Methods of Data Collection 9
2.4.1 Primary Data 10
2.4.2 Secondary Data 10
2.5 Techniques of Data Collection 11
2.6 Data Needs 11
2.7 Techniques of Data Analysis 13
2.8 Presentation of Results of Data Analysis 13
2.9 Ethical Considerations 14
CHAPTER THREE: LITERATURE REVIEW 15
3.0 Introduction 15
3.1 Concept of Wetlands 15
3.1.1 Classification of Wetlands 16
3.1.2 Role of Wetlands Sustainable Environment 19
3.1.3 Threats and Loss to Wetlands 20
3.1.4 Evolving Challenges of Wetlands 21
3.1.5 Wetland Loss Mitigation 21
3.1.6 Concept of Land Use 22
3.1.6.1 Rural Catchment Land Use 23
3.1.6.2 Urban Catchment Land Use 24
3.1.7 Implications of Catchment Land Use Activities on Wetlands 25
3.2 Theoretical Approaches to Wetlands as a Natural Resource 25
3.2.1 Economics of Natural Resources 25
3.2.2 Garrett Hardin's Tragedy of the Commons 27

3.2.3 The Value-Belief-Norm Theory of Environmentalism.....28
3.3 Effects of Rural Catchment Land Use Activities.....29
3.4 Effects of Urban Catchment Land Use Activities.....30
3.5 Role of Land Use Planning 31
3.5.1 Optimization of Land Use in Wetlands 32
3.5.2 Concept of Sustainability in the Use of Land 32
3.6 Sustainability Strategies for Coexistence of Urban and Rural Land Uses....33
3.7 Identified Gaps in Theory on Wetlands 33
3.8 Policy, Legal and Institutional Framework 34
3.8.1 Policy Context of the Study 34
3.8.1.1 Wetlands Conservation and Management Policy, 2015.....34
3.8.1.2 Sessional Paper No. 6 of 1999.....35
3.8.1.3 Sessional Paper No. 3 of 2009 on National Land Policy.....35
3.8.1.4 Kenya National Spatial Plan 2015-2045 36
3.8.1.5 Sessional Paper No. 1 of 2017 on National Land Use Policy 37
3.8.2 Legal Context of the Study 38
3.8.2.1 The Constitution (2010).....38
3.8.2.2 Environmental Management and Coordination Act,1999(Amended in 2015) 39
3.8.2.3 Forest Conservation and Management Act, 2016 39
3.8.2.4 The Land Act No. 6 of 2012.....40
3.8.2.5 The Water Act, 2016 40
3.8.2.6 Kenya Water Tower Agency Order, 2012.....40
3.8.2.7 Water Quality Regulations, 2006 41
3.8.2.8 County Government Act No. 17 of 2012 41
3.8.2.9 Physical Planning Act (CAP 286) 42
3.8.2.10 The Crops Act, 2013.....42

3.8.2.11 Irrigation Act, 2019 (No. 14 of 2019) 42
3.8.2.12 Agriculture Act (Cap. 318).....42
3.8.2.13 Agriculture (Farm Forestry) Rules,2009 43
3.8.2.14 The Urban Areas and Cities Act, 2011.....43
3.8.3 International Treaties, Conventions and Multilateral Environment Agreements (MEAs).....43
3.8.3.1 The Ramsar Convention 43
3.8.3.2 Framework Convention on Climate Change 44
3.8.3.3 Sustainable Development Goals.....44
3.8.3.4 African Eurasian Water Bird Agreement (AEWA).....45
3.9 Summary of the Theoretical Background 45
3.10 Conceptual Framework 45
CHAPTER FOUR: STUDY AREA 48
4.0 Introduction 48
4.1 Brief History.....48
4.2 Geographical Location 48
4.2.1 National Setting 49
4.2.2 Regional Context 50
4.2.3 Sub-County Context 51
4.2.4 Ward Context.....52
4.2.5 Ondiri Swamp Neighbourhood Context.....53
4.2.6 Ondiri Swamp.....55
4.3 Climate 57
4.4 Topography 57
4.5 Influential Human Factors.....61
4.5.1 Demographic Dynamics.....62
4.5.2 Socio-Economic/Cultural Profiles 64

CHAPTER FIVE: DATA ANALYSIS AND RESULTS 65

5.0 Introduction 65

5.1 General Description of the Sample 65

5.2 Land Tenure in the Study Area 65

5.3 Land Use Types in the Study Area.....67

5.4 Land Cover Analysis in the Study Area.....68

5.5 Conclusion.....74

CHAPTER SIX: FINDINGS, CONCLUSIONS AND RECOMMENDATIONS.....75

6.0 Introduction 75

6.1 Summary of Findings 75

6.1.1 Findings on Rural Land Use Activities in the Rural Community Affecting Ondiri Swamp.....75

6.1.2 Findings on Urban Land Use Activities in Kikuyu Town Affecting Ondiri Swamp 78

6.1.3 Findings on the Factors Contributing to Rural and Urban Land Use Activities in 6.1.1 and 6.1.2.....81

6.1.3.1 Overexploitation of the Wetland Resource 81

6.1.3.2 Uncoordinated Stakeholder Efforts and Overlapping Institutional Mandates 81

6.1.3.3 Inadequate Linkage Between Research, Planning and Policy Development.....82

6.1.3.4 Weak Law Enforcement 82

6.2 Summary of Conclusions 82

6.2.1 Conclusions on Rural Land Use Activities in the Rural Community Affecting Ondiri Swamp 84

6.2.2 Conclusions on Urban Land Use Activities in Kikuyu Town Affecting Ondiri Swamp.....85

6.2.3 Conclusion on the Factors Contributing to Rural and Urban Land Use Activities.....86

6.3 Recommendations 87

6.3.1 Recommendations on Rural Land Use Activities in the Rural Community Affecting Ondiri Swamp 87

6.3.2 Recommendations on the Urban Land Use Activities in Kikuyu Town Affecting Ondiri Swamp 88

6.3.3 Recommendations on the Factors Contributing to Rural and Urban Land Use Activities 89

6.4 Contribution to Knowledge 92

6.5 Areas for Further Research 92

References 93

APPENDICES 98

Appendix 1: Research Work Plan 98

Appendix 2: Research Budget Estimates 99

Appendix 3: Household Questionnaire 100

Appendix 4: Key Informant Guide 107

Appendix 5: Observation Checklist 111

Appendix 6: National Environment Management Authority (NEMA) Report on Water Quality in Ondiri Swamp 113

Appendix 7: Survey Plans used to define the Boundary of Ondiri Swamp 115

LIST OF FIGURES

Figure 1: Geographical Location of Ondiri Swamp 6
Figure 2: Satellite Image Showing the 2km Radius Buffer 9
Figure 3: Figures Showing the Development of a Quacking Bog 18
Figure 4: Wetlands Loss Mitigation 22
Figure 5: Interdependence Between the Economy, Society and the Environment.....26
Figure 6: Conceptual Framework 47
Figure 7:National Context of Ondiri Swamp.....49
Figure 8:Regional Context of Ondiri Swamp 50
Figure 9:Sub-County Context of Ondiri Swamp 51
Figure 10: Ward Context of Ondiri Swamp.....52
Figure 11: Ondiri Swamp and the Neighbourhood.....54
Figure 12: Outline of Ondiri Swamp 56
Figure 13: Elevation Map of Ondiri Swamp.....58
Figure 14: Drainage System of The Catchment Area 60
Figure 15:Population Density Map 63
Figure 16: Land Tenure System.....66
Figure 17: Existing Land Uses in the Study Area.....67
Figure 18: Land Use Distribution 68
Figure 19: Land Cover Distribution in 2002.....69
Figure 20: Land Cover in 2002 70
Figure 21:Land Cover Distribution in 2022.....71
Figure 22: Land Cover in 2022 72
Figure 23: Percentages of Land Uses Adjoining Ondiri Swamp 73

LIST OF TABLES

Table 1: Coverage of Land Uses Adjoining Ondiri Swamp 73

LIST OF PLATES

Plate 1: Swampy Area at Rockrun Preserve, USA 16
Plate 2: An Image Showing Marshes 17
Plate 3: Ouse Fen Reserve in England 19
Plate 4:Green Houses and Farmlands Creeping to the Edges of the Swamp 76
Plate 5:Tree Stumps of Felled Trees within the Study Area 77
Plate 6:Increased Population and Developments on Land Adjoining Ondiri Swamp . 78
Plate 7: Events Taking Place At The Periphery Of Ondiri Swamp 79
Plate 8:Storm Drainage Along the Southern Bypass Near The Wetland 80
Plate 9: Water Flowing Out of Ondiri Swamp 84
Plate 10: Dumping Near the Wetland 86
Plate 11: Net for Trapping Litter 89
Plate 12: The Three-Zone Buffer Concept to Protect the Wetland 90

ACRONYMS

AEWA	African Eurasian Water Bird Agreement
DEM	Digital Elevation Model
EEA	European Environmental Agency
EIA	Environmental Impact Assessment
ESA	Ecologically Sensitive Area
GIS	Geographical Information Systems
GoK	Government of Kenya
IBA	Important Bird Area
MEA	Multi-Lateral Environmental Agreement
NEMA	National Environmental Management Authority
NLC	National Lands Commission
SRTM	The Shuttle Radar Topography Mission
USGS	United States Geological Survey
WRA	Water Resources Authority

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Wetlands are regions where water covers the soil, is present on the surface of the soil, or exists intermittently throughout the year. The prolonged and persistent presence of water creates circumstances that support both aquatic and terrestrial species. Wetlands vary greatly because of changes in soil, terrain, climate, hydrology, water chemistry, flora, and other elements at the regional and local levels. Throughout history, humans have used wetlands to directly derive a variety of goods and services for their economic well-being at the household, community, and national levels (Mahlatini et al., 2018). Indirect benefits also exist as wetlands serve as natural sponges that confine and gradually let out water over time and aid in regulating floods. Also, they purify water, retain moisture and provide time for water infiltration for groundwater replenishment (Rafiq et al., 2014).

A vast diversity of species of plants, microbes, mammals, insects, reptiles, fish, amphibians, and birds reside in wetlands, including some endangered and rare species. Plants growing in wetlands offer bird nesting areas and shelter to protect prey species against predators, as the waters provide habitation for fish and shellfish. In addition, some species spend their entire lives in wetlands, whereas others visit for breeding purposes or to raise their offspring (Gambrel, 2019).

Overall, environmental amenities that wetlands avail to immediate communities and distant users in addition to tangible and intangible economic and ecological values regionally and even globally are immense. However, they are at a breaking point. According to the United Nations Climate Change, around 35% of the globe's wetlands vanished from 1970 to 2015, with the loss rate increasing annually from 2000 to date. Losses have significantly been powered by an increase in population, and a turnaround in consumption patterns resulting in changes in agriculture, water and land utilization, urbanization, and climate change. The globe's persisting wetlands are also under threat because of pollution, invasion by some species, sedimentation resulting from deforestation, disrupted flows from dams, and upstream soil erosion.

Generally, these losses are caused by consumer externalities instituted on other stakeholders, the public nature of a majority of wetland services and products, and implementation failure of policy interventions due to inconsistency among government

policies in various sectors, including physical planning, environment, economics, and poor nature of protection (Turner et al., 1998).

The wetland ecosystem destruction, especially in the Ondiri swamp, can be dated back to the colonial period, characterized by the extensive destruction of forests. The Ondiri wetland stands on the periphery of the urban jungle in the early 1900s because of the Kenya - Uganda railway line. Like many wetlands worldwide, Ondiri Swamp has been extensively exploited as a water source. With it being located just a kilometre away from Kikuyu Township, the swamp is faced with urban and rural fringe effects. Additionally, the surrounding area has one of the rapidly growing populations due to urban influence. This rapid population growth coupled with uncontrolled human activities continues to exert pressure to the level of endangering its long-term conservation and as a powerhouse of ecosystem services.

As the pressures continue, the wetland ecosystem is being encroached upon and deteriorated because of the frail institutional environment and its policies, limited functions, and diverse knowledge and exploitation among experts and land users.
The Global Wetland Outlook report stresses the need to draft efficacious wetland management strategies and assimilate wetlands into the national strategy on climate change, sustainable growth, and other significant global commitments. Therefore, it is essential to properly determine the wise use of fragile environmental ecosystems before their ecological functions and properties are entirely transformed.

1.2 Statement of the Research Problem

The loss of wetlands continues to transpire to date, with direct and measurable adverse effects on nature and the human population (Finlayson et al., 2018). The few prevailing wetlands worldwide are endangered by agriculture, invasive species, developments in housing, agricultural run-offs, wastewater affluence, and stormwater. These threats cause changes within the fragile environmental ecosystem, resulting in dramatic habitat conversion that has significant immediate and long-term impacts on the wetland's biological resources and ecological integrity.

Currently, Ondiri Swamp is highly threatened by various activities within its ecosystem; this encompasses unrestrained water abstractions and solid waste dumping. Also, numerous water pumps in the wetland's surroundings are not metered; therefore,

it is impracticable to keep track of the water extraction levels. Major agricultural activities also occur, including the establishment of greenhouses that have crept to the edges of the swamp. The use of fertilizers and agrochemicals is every day. Again, it is guessed that the water quality and quantity from the wetland have been deteriorating over the years.

The Southern bypass road was built within the wetland ecosystem, and many trees were cut down to pave the way for the development. During the rainy season, Ondiri Swamp is extensively exposed to contamination. This is because the highly populated Kikuyu town is not entirely connected to the recently installed sewerage system; nearby residential houses use the stormwater spillways of the southern bypass road to release urban effluents into the wetland. Again, the steep slope to the swamp experiences high soil erosion rates, leading to higher sedimentation rates in the swamp (Kinyanjui, 2003).

Despite its unique standing, the wetland has no legal protection and no proper land-use plan to protect it. Competing urban and rural land uses are the predators of the Ondiri Swamp. Land-use planning of these competing land uses is characterized by three significant shortcomings: neglect of methodology, a comparative absence of systematic analysis of the technical and theoretical aspects of planning, and a lack of enthusiasm in clarifying fundamental concepts involving the wise utilization of the wetland.

1.3 Research Questions

The following research questions were formulated for the study:

1. What rural land use activities in farmland bordering the Ondiri Swamp affect its ecological functions or properties as a wetland?
2. What urban land use activities in Kikuyu town and built properties at sites bordering the Ondiri Swamp affect its ecological functions or properties as a wetland?

1.4 Research Objectives

The study aimed to achieve one overall objective and four specific objectives.

1.4.1 Overall Objective

The study's overall objective was to assess the rural and urban land use fringe effects on Ondiri Swamp.

1.4.2 Specific Objective

The study has been guided by the following four specific objectives:

1. To find out rural land use activities in the rural community bordering the Ondiri Swamp that affect the wetland's ecological functions or properties.
2. To find out urban land use activities in Kikuyu town and properties at sites bordering the Ondiri Swamp that affect the wetland's ecological functions or properties.
3. To appraise the factors contributing to rural and urban land use activities in (1) and (2) above, respectively, with a view to ranking and prioritizing them for intervention; and
4. Proposing land use planning interventions for land use activities negatively affecting ecological functions or properties of Ondiri Swamp.

1.5 Assumptions of the Study

The study has three assumptions. Ondiri Swamp is an environmentally fragile ecosystem affected by the rural-urban environment. The rural land use activities are mainly agricultural, whereas the urban effects are from the fast-growing and highly urbanized Kikuyu Town. Moreover, experts and land users have not distinctively determined the urban and rural land use activities to protect Ondiri Swamp. Finally, there are no policies giving guidelines on wetland conservation. Ondiri Swamp is not legally protected because it has not been gazetted yet.

1.6 Justification of the study

Wetlands are dynamic zones open to influence by the human population and nature and subject to degradation and loss attributable to humankind's developmental undertakings on the landscape, such as urban expansion and agricultural activities. They can alter the

functions and conditions of the wetlands by disrupting and disintegrating natural hydrological pathways besides affecting the quality of the water within the wetlands.

To maintain the wetlands' productivity and biodiversity and allow for the logical and informed utilization of their resources, there is a dire need to manage and conserve them. Effective management must be based on the comprehension of the components of the site with respect to the species and habitats and the interactions of these components, the ecosystems that arise from their interactions, and the processes that endanger and sustain them. Also, the management must specifically comprehend and present human utilization, its immediate and future effects, and how optimal utilization can be achieved.

1.7 Significance of Study

Looking at the future impact of land uses, urban and rural fringe effects are likely to cause pressure on wetlands as the population around wetlands increases. Therefore, effective management of wetlands is necessary to comprehend the extensive actions and measures needed to sustain the wetland and place it positively in the locality and any development in the surrounding area.

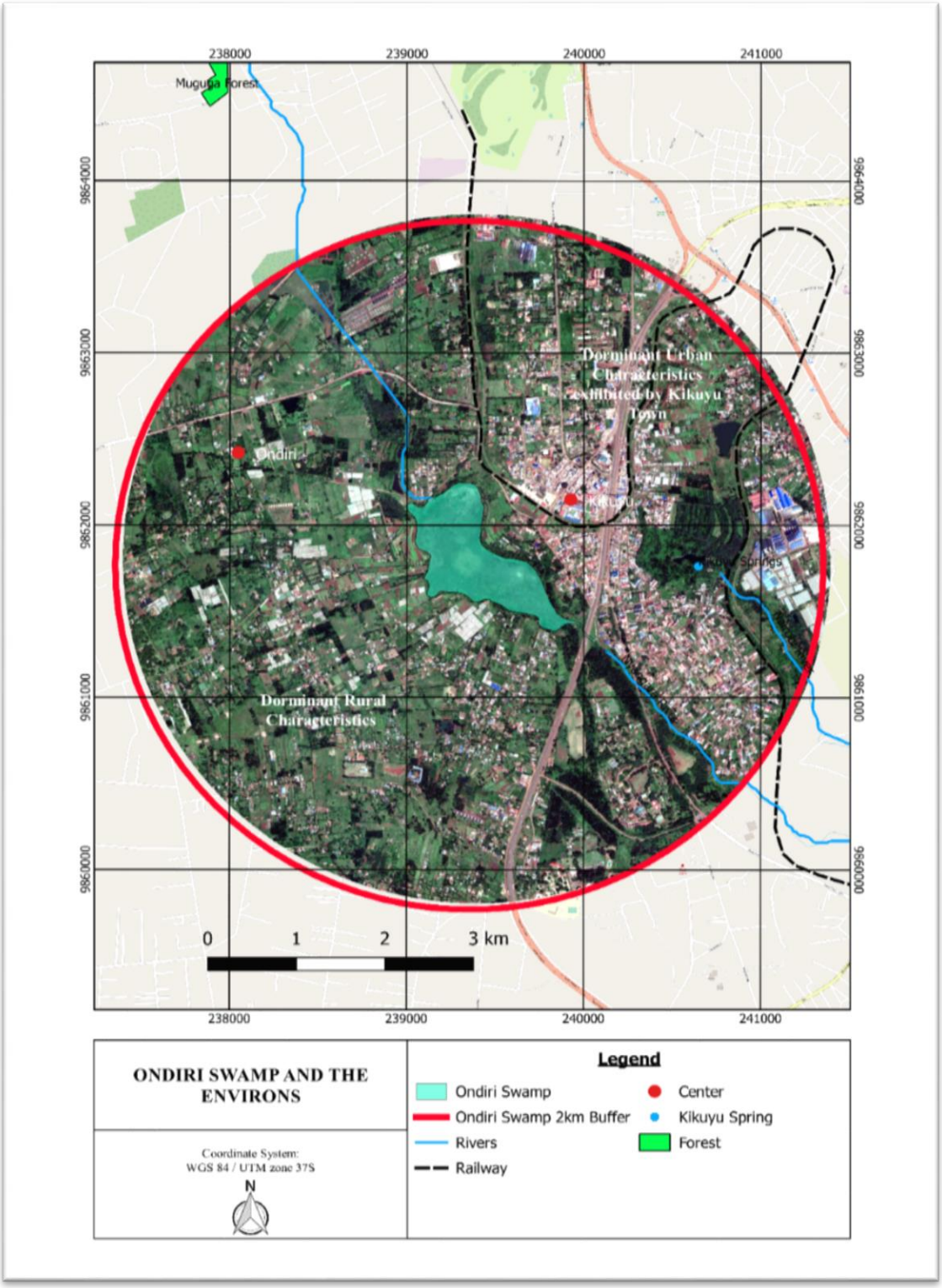
1.8 Scope of the Study

This section covers the geographical scope and the theoretical scope of the study.

1.8.1 Geographical Scope of the Study

The study is limited to the Ondiri Swamp area and its environs. The environs include the land bordering the wetland as their land use types which include urban and rural land uses have a direct impact on Ondiri Swamp and the wetland ecosystem. Therefore, the area deemed to have a direct impact is a buffer zone of a 2km radius from Ondiri Swamp as shown on Figure 1.

Figure 1: Geographical Location of Ondiri Swamp



Source: (Author, 2022)

1.8.2 Theoretical Scope of the Study

The study centered on the characteristics of physical structures, activities, and practices that are affiliated with the wetland's physical extent and ecological nature. The study is thus intended to address concerns of sensible use and management of Ondiri Swamp by focusing on the diverse rural and urban land uses that surround the wetland.

1.9 Key Terms

Land: The area of solid ground that forms the surface of the earth.

Land use: Sustainable land use involves balancing human activities and natural resources and adapting the land surface to fulfill the needs of current and future generations (Njogu et al, 2006).

Wetland: An area saturated and covered with water, usually groundwater, seeping up from a spring or an aquifer.

An ecosystem: A collection of living organisms in a particular space and how they interact with one another and their physical surroundings.

Appraisal: The act of assessment.

A Catchment Area: The region of land where water enters into a river, lake, or reservoir.

Encroachment: This is a gradual advance beyond usual or acceptable limits into the possessions or rights of another.

1.10 Organization of the Study

The study is organized into six chapters. The first chapter is the introduction which introduces different aspects of the study, the second expounds on the techniques, strategies, and overall methodology used in the collection, analysis and presentation of the data, the third involves the reviewing of literature which gives insight into the secondary information collected during the study, the fourth looks at Ondiri Swamp and the bordering land use types as part of the ecosystem, which directly impacts the ecological functions and properties of the wetland. The fifth chapter is the presentation and analysis of the results of the data gathered and finally, the sixth chapter covers the findings, conclusions, and recommendations.

CHAPTER TWO: RESEARCH METHODOLOGY

2.0 Introduction

This chapter opens with a depiction of theoretical viewpoints that influenced research design and the target population of the study. The chapter also discusses sampling methodology, data requirements, data collection methods, data collection techniques, data analysis strategies, and data analysis findings presentation to meet the objectives.

2.1 Research Design

The study employed both quantitative and qualitative methodologies. The social reality under investigation required observation of the natural world as well as interpretation of unique, individual, and qualitative qualities. In this regard, a mixed-method approach was eventually chosen for the study.

Induction was used to investigate emerging patterns, implying links between the wetland and other phenomena observed and experienced by stakeholders. The study's linkages and generalizations were established using the findings of inductive reasoning. As a result, the study's research methodology was influenced by several elements, including the necessity to investigate the wetland's ecological characteristics as well as its ecosystem. An interpretive perspective was also required to study the many roles, views, and behaviors of major characters in their natural

2.2 Target Population

The Ondiri Swamp and its surroundings are the study area with the target population. The surroundings include Kikuyu Town and the rural community bordering Ondiri Swamp. For this study, the sample size was determined by the stakeholders, who in this case were the landowners and land users surrounding the wetland. Three distinct sample regions, consisting of institutions, study sites, and experts, were chosen to ensure that all research questions were fully addressed.

2.3 Sample Size and Sampling Plan

The sampling frame was designed for both rural and urban land usage, with samples taken within a 2-kilometer radius around Ondiri swamp illustrated in Figure 2. The study used simple random sampling for both land uses and adhered to Mugenda and Mugenda's (2003) criteria, which stated that for descriptive studies, a sample size of

10% of the available population is adequate to provide data. A great emphasis was however placed on all the current land use activities and landowners adjoining Ondiri Swamp.

Figure 2: Satellite Image Showing the 2km Radius Buffer

Source: (Google Earth, 2021)

2.4 Methods of Data Collection

Data sources are categorized into primary and secondary categories. In this study, both sources were used to complement one another.

2.4.1 Primary Data

Primary data was gathered and recorded in its natural environment. Data collection instruments were designed to acquire qualitative and quantitative data depending on the study's objectives. Methods including observations, household interviews, key informant interviews and a participatory planning workshop were conducted.

Observation is a means by which a researcher uses their senses of sight, hearing, smell, touch and taste to gather information. It is also useful in reviewing and vetting information collected through other data collection methods with on-ground observations. Observation schedules were utilized to collect data and gain useful insights into the wetland's physical expanse, biological health, major land uses, and human activities surrounding Ondiri Swamp.

Household interviews were carried out using both structured and semi-structured predetermined questions that made up the questionnaire. The structured questions were straightforward to administer and led to structured feedback that was easy to analyse. The semi-structured questions were open-ended and helped explain and describe situations in their preferred way without being prompted by the researcher.

Informant Interviews were conducted to get qualitative data from professionals and administrators in the study region. The interviews were however semi-structured to provide room for flexibility, and follow-up questions as well as to pursue new lines of questioning.

A participatory planning workshop involving the community around Ondiri Swamp was conducted. The participants expressed their opinions and highlighted their ideas after being guided through a series of structured questions involving the study.

2.4.2 Secondary Data

The study collected secondary data using an archive approach and document analysis. The procedure involved examining secondary data in existing documents and records.The literature review approach looked for and examined wetlands, specifically the difficulties surrounding the Ondiri Swamp.

2.5 Techniques of Data Collection

Data collection techniques allude to the behaviour and instruments used in conducting the research such as making observations, conducting interviews, recording and analyzing data. The techniques applied in this study include mapping, the use of questionnaires and photography.

Mapping was used to spatially represent specific aspects defined in the study area such as the geographical location, the extent of Ondiri Swamp, population distribution, drainage and relief. The use of GIS was highly exploited.

The household questionnaire used in the household interviews was uploaded on the Kobo Collect application and the software used to administer the questionnaire.

Photography was used to amplify evidence as observations were being made. The process involved capturing photographs of various aspects observed and noticed in the areas of interest.

2.6 Data Needs

Data pertaining to personal profiles, roles, behavior, and attitudes of individuals residing in households, as well as professionals, were collected. This data specifically focused on their current land use and tenure, physical infrastructure, adherence to policies and laws, and their level of engagement and participation in wetland protection and conservation. Data requirements covered both gaps in present management plans and future wetland management strategies.

The specialists that worked on the project included physical planners, land surveyors, environmentalists, and property managers. The survey includes people from both public and private properties.

Institutional data were also acquired from Kiambu County, the Water Resources Authority (WRA), the Departments of Lands, the National Environment Management Authority (NEMA), the Ministry of Lands' Physical Planning and Surveys, and the various sub-county offices.

The data collected included information on land use, land use densities, data on land administration, and biophysical parameters in the vicinity of the wetland zone as well as within the buffer zone that was two kilometers around the wetland. Residential, commercial, industrial, institutional, and agricultural land uses were the primary

surrogates of land use that were investigated in this study. In addition to open spaces, there were also other sorts of land usage.

The land use density data was used to evaluate the spatial concentration around Ondiri Swamp. The information was obtained through field observation as well as data mining from the Open Buildings website. The website includes a recent collection of building footprints, which is an important component for determining population density. These building footprints are constructed using high-resolution satellite imagery and machine learning technologies, then published on the internet.

The land administration data comprised both land tenure and cadastral datasets. The household questionnaire was used to collect data on formal land tenure. The cadastral database included specifications such as the measurements, shape, and size of every single individual unit of land. Additionally, this information was incorporated into validated survey designs that were obtained from the Department of Surveys. This information was extremely useful because it showed the limits of specific parcels of land in respect to the Ondiri Swamp. Digitizing the cadastral dataset collectively contributed to the correct and actual boundaries of Ondiri Swamp.

The existence of vegetation covers, soils, and slopes are all important ecological features that influence how wetland habitats function. These parameters indicate the current ecological conditions. Surrogates for ecological conditions included the presence or absence of plant cover, solid waste, and wastewater, as well as incompatible physical structures and human activities inside the two-kilometer buffer zone surrounding Ondiri Swamp. These factors were viewed as substitutes for ecological circumstances. The vegetation cover was examined and recorded according to schedule. The vegetation cover was classed as forest land, cropland, or barren land. The data on ecological conditions was gathered by photography and observation, and it was subsequently expanded through analysis of land use and land cover areas. Satellite imaging data for the land use and land cover analysis were obtained from the United States Geological Survey's (USGS) Earth Explorer website.

The USGS Earth Explorer provided a quick and easy way to download aerial and satellite images data in chronological order.

The study area's terrain was constructed using a Digital Elevation Model (DEM) retrieved from the SRTM Worldwide Elevation Data in the Global Mapper software. The DEM was utilized to compute the contours of the research region.

The National Environmental Management Authority (NEMA) aided in the collection of water quality data. Water samples were collected at several points surrounding Ondiri Swamp and analyzed at the NEMA facilities.

Other forms of data and their sources include policy and legal data derived from published journals, research, laws, and regulations from Kenya and other countries, which were regarded as sources of best practices in wetlands determination, use, and management policies.

2.7 Techniques of Data Analysis

Desktop qualitative, statistical, and geographical analysis were utilized throughout the course of the project. The method of content analysis was utilized to conduct the study of qualitative data. Statistical analyses were carried out to assist in making inferences about different variables in the study area. Remote Sensing Analysis and Geographical Information System Analysis (GIS) Analysis were used to appraise territorial, physical coverage, and various aspects of encroachment on the wetland. The analysis was done to assess land-use changes and land cover around the Ondiri Swamp ecosystem. The purpose was to determine the rate of change of land use types bordering the wetland, including cropland, forested area, settlements, and built-up area. Unsupervised satellite imagery classification in Remote sensing was used to classify the land use types.

For providing a visual representation of the relationship between variables, quantitative data was summarized in percentages and presented in graphical form using tables, maps, and charts. The information from the landowners and users neighbouring the wetland was analyzed and linked to the land-use types to define and use activities exerting pressures on the wetland.

Another analysis was done by the Ondiri Swamp water quality tests. On the results of the water quality, the experts from the NEMA laboratory helped in interpreting the results for the purpose of this study.

2.8 Presentation of Results of Data Analysis

The focus of this analysis was on the attitudes of professionals about conservation and the responsible utilization of wetland areas. Quantitative data in this study is presented

in tables, charts, and maps whereas Qualitative data is presented in narratives with themes based on the study's objectives.

2.9 Ethical Considerations

When conducting the research, the study adhered to the principle of voluntary participation, which states that individuals should not be coerced into taking part in the study. After that, the study participants were enlightened on the research's procedures and risks involved and they were willingly given their consent to participate in the study.

Ethical standards also require that researchers do not place participants in any compromising situations that could lead to psychological or physical harm as a result of their involvement in the study.

The research also guaranteed the prudence of the participants' information by ensuring that their information would be protected and not shared with anyone not directly involved in the study.

Also, the principle of anonymity was implemented. Ideally, the participants remain anonymous during the whole period of the study.

In addition, the participants were required to maintain reasonable physical distance and wear a mask during the research process adhering to the COVID-19 protocols given by the Ministry of Health.

Finally, to ensure ethical considerations in spending for travel, printing, research assistants, data acquisitions and field facilitations, the research process maintained transparency, adhered to budget constraints, prioritized fair wages for assistants and ensured responsible data acquisition practices as tabulated in Appendix 2.

CHAPTER THREE: LITERATURE REVIEW

3.0 Introduction

This chapter factors in an analytical evaluation of relevant literature concerning wetlands and is informed by the study objectives. The review lays a foundation for data collection and analysis.

3.1 Concept of Wetlands

According to Zedler and Kercher (2005), scientists globally have not agreed on the definition of wetlands; however, most of their definitions are inclined to a hydrologic aspect. Also, the constituents of wetlands have not been globally agreed upon. This has been epitomized by the definition of wetlands by Moore and his co-authors. They state that wetlands are areas where water supports the surrounding biota of a location and its environment. In this, water is highlighted as the primary factor in determining a plant's life alongside the presence of nutrients and sunlight (Moore et al., 1999). Therefore, it is possible to define what a wetland is. Still, it is impossible to pick a single definition since it wouldn’t encompass the various kinds of wetlands into one.

According to Matthews and Luthi (1993), the Ramsar Convention on Wetlands plays a critical role internationally by providing definitions that broadly describe wetlands and efforts to conserve the wetlands. The definitions of wetlands as per the Ramsar Convention on Wetlands are "Wetlands are areas of peatland, water or fen, whether natural or artificial, temporary or permanent, with flowing water or static, salty or fresh, inclusive of places of marine water with a depth not surpassing six meters during low tides. Wetlands may include coastal and riparian zones next to either marine water bodies that don't surpass six meters at low tides or wetlands."

Other definitions include “Wetlands are transitional areas that are found in between properly drained uplands and areas permanently flooded with deep waters, where the land is covered with waters that are shallow or the water table is close to the surface of the land." Examples of wetlands are; marshes, whether salty, fresh, or intermediate, mangroves, bogs, forested wetlands, swamps, and wet prairies (Gerbeaux et al., 2018).

The European Environmental Agency has embraced this definition in its working program (EEA 1999). The US-Environmental Protection Agency expounds wetlands in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands (1989)

as follows; Those places that are saturated or flooded with ground or surface water at a regular and period adequate to support, and that under conventional conditions do support, a widespread presence of vegetation normally habituated for growth and survival in saturated soil set up. Generally, wetlands comprise bogs, marshes, swamps, and similar areas.

3.1.1 Classification of Wetlands

According to Gerbeaux et al. (2018), classifying wetlands into various categories has proven to be a significant challenge. However, scientists consider the following as the major types of wetlands: swamps, fen, bog, and marsh.

A swamp is described as "a wetland continually saturated with water, dominated by trees with a matured leaf canopy." Swamps can either be freshwater or salty water swamps. Freshwater swamps are majorly found in tropical areas close to the equator, and they form in flat areas around lakes or streams where the runoff is relatively slow, and the water table is high. On the other hand, salty water swamps are majorly found on tropical coastlines. The emergence of saltwater swamps starts with sand or mud being covered thinly during high tides by seawater.

An example of a swampy area is shown on Plate 1.

Plate 1: Swampy Area at Rockrun Preserve, USA

Source: (Forest Preserve District of Will County, 2020)

Marshes are defined as "wetlands continually or often saturated with water, distinguished by the emergence of herbaceous vegetation stemming from hydric soils." Various marshes range from saltwater to freshwater, inland to coastal, and Everglades to prairie potholes. However, marshes are broadly categorized into two, tidal and non-tidal marshes. Tidal marshes are majorly found in secured coastlines in the high or middle-latitude areas worldwide, with a high prevalence on the eastern coast of the United States from Maine to Florida and extending to Texas and Louisiana situated on the Gulf of Mexico (Broome et al., 2019). They are either brackish, saline, or freshwater. Non-tidal marshes, on the other hand, are prevalent in North America and are primarily freshwater. An example of a marshy area is shown on Plate 2.

Plate 2: An Image Showing Marshes

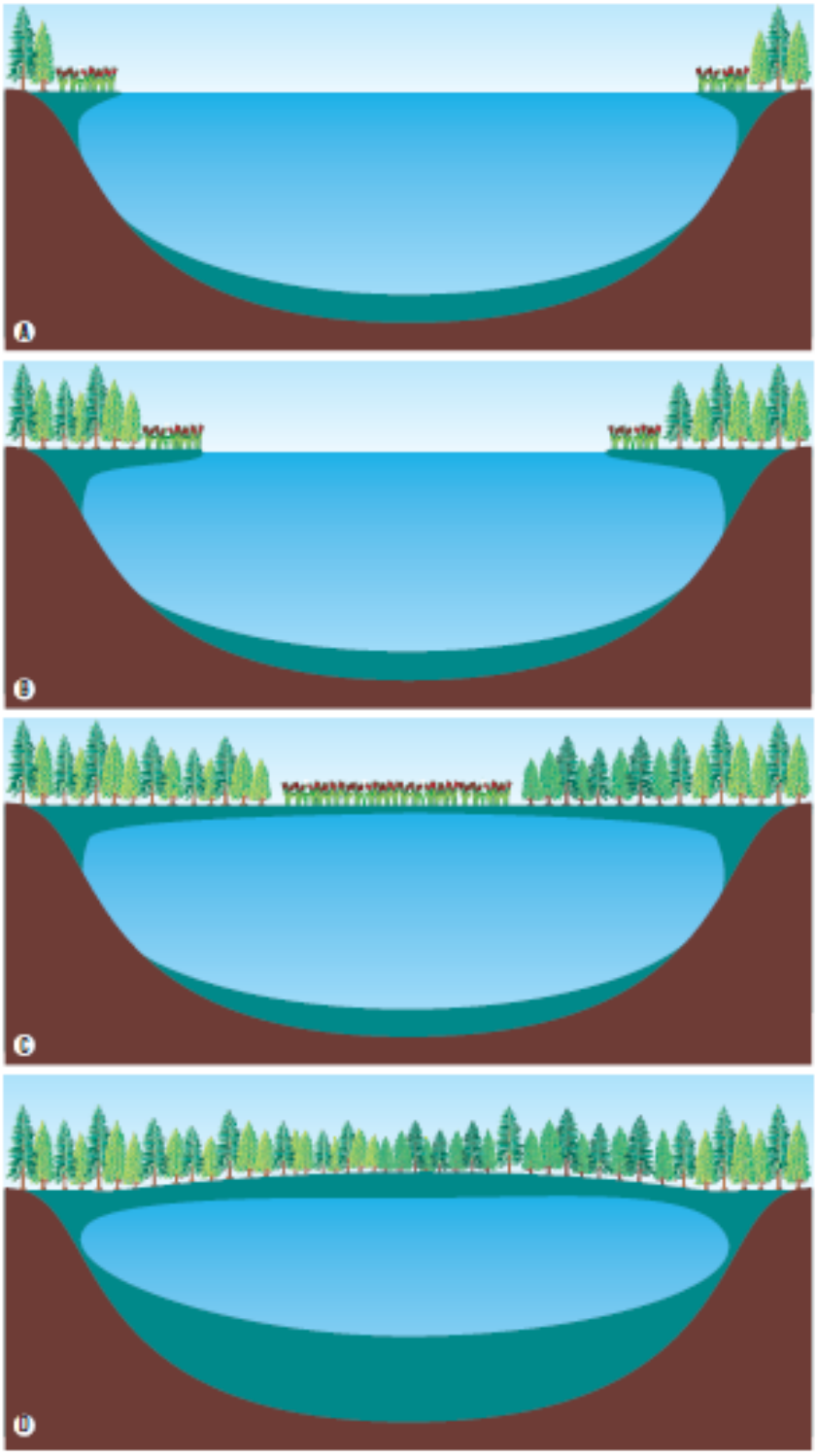
Source:(Yale Climate Connections Team, 2019)

According to Amani et al. (2017), a bog is a wetland dominated by peat and dead plant material deposits, primarily mosses that form a floating carpet surface.

The surface shakes when you walk over it as the vegetation carpet is only a few feet thick and overlies a water body. This type of wetland is sometimes referred to as a quaking bog. A quaking bog comes about when the small, steep-sided basins are overrun by floating vegetation around their edges (A) and (B) in the Figure 3 below. In

due course, the floating raft of vegetation spreads and covers the whole lake (C), resulting in a floating mat of peat and rhizomes (D)

Figure 3: Figures Showing the Development of a Quacking Bog



Source: (Moore, 2006: Biomes of the Earth: p.23)

Bogs are commonly found in cold areas or Arctic areas of Europe, North America, and Asia. However, they are also found in warmer regions in the United States, such as the Sierra Nevada. Like most wetlands, bogs are prone to develop where the water table is high.

On the other hand, a fen is a wetland that is peat-forming and is fed by underground and surface water and dominated by grass and sedges as seen in Plate 3. Fens are mainly freshwater.

Plate 3: Ouse Fen Reserve in England

Source: (The Royal Society for the Protection of Birds, 2021)

3.1.2 Role of Wetlands Sustainable Environment

Wetlands are a crucial part of both our lives and our natural ecosystem. Ideally, wetlands provide essential and helpful amenities to people, wildlife, and fish. First, wetlands play an indispensable role in the ecology of watersheds. The integration of high amounts of nutrients, shallow waters, and primary productivity are essential for the growth and development of organisms that constitute the starting point of food webs, thus feeding amphibians, fishes, and insects. Secondly, wetlands naturally protect and help humans in various ways; protection from flooding, availing recreational opportunities, controlling erosion of the shoreline, retaining and refining the quality of natural water (Mucheye et al., 2018). Also, wetlands provide natural products that,

when sold, eventually help in growing and sustaining the economy. The wetlands provide natural products that include blueberries, fish, cranberries, wild rice, and timber. Also, some wetlands provide medicine obtained from their soils or plants.

According to Trišić (2019), wetlands offer individuals tourism opportunities; people can visit either for aesthetics or recreational purposes. In turn, these tourism opportunities aid in the growth of the economy. Also, wetlands aid in the maintenance of the atmosphere. Wetlands help atmospheric maintenance by preventing global climatic changes as wetlands cumulate their carbon dioxide within their soils or plants rather than releasing it into the atmosphere. Wetlands also serve as a food source, habitat, and breeding ground for plants and animals. Certain mammals, marine and estuarine fish, and some birds require a coastal wetland for survival. Also, animals and plants such as swamp-rose, muskrats, and wood ducks can only reside in inland wetlands. Lastly, wetlands help mitigate storms and generally reduce the damage that comes with storms. They absorb water in the rainy spans and release it gradually during the dry duration.

3.1.3 Threats and Loss to Wetlands

According to McCullough (2018), countries globally continue to experience losses and threats to their wetlands due to various reasons for humans, animals, and plants. Construction of roads or dikes can result in vandalizing consequences on wetlands if they alter the flow of a pattern of water or interfere with the movement of aquatic animals. Also, drainage canals constructed for agricultural purposes can significantly interfere with the hydrology of wetlands, turning them into uplands. Pollution caused by humans' constant littering or oil spills leads to the degradation of wetlands and surrounding aquatic habitats (Bezabih and Mosissa, 2017). Invasion by exotic animals such as nutria (a rodent) is also a threat to the wetlands. These rodents burrow into banks and consume a large amount of vegetation down to their roots, generally altering the plants and resulting in banks and soil erosion. Livestock grazing that is not closely monitored can also threaten the wetlands as animals can interfere with banks that stabilize the wetlands resulting in bank or soil erosion. Also, the frequent withdrawal of groundwater from wetlands diminishes levels of water in these wetlands, interfering with the habitats for fish, plants, and other aquatic life.

Ideally, these threats and losses to the wetland ecosystems result in increased nutrient runoff, floods, damage resulting from storms, erosion of the shoreline, and water pollution. Also, various countries' economies have become at stake, especially those relying upon fishing, recreation, and hunting as their primary economic activity. Therefore, the restoration of the compromised wetlands is very crucial.

3.1.4 Evolving Challenges of Wetlands

Wetlands are among the most delicate habitats worldwide. They are delicately balanced and in sync with their environment, establishing their ecosystem. Also, they are affected by any changes that may occur, however small, either in the water supply, atmosphere, or neighbouring land uses.

According to Moore (2006), wetlands are very vulnerable and fragile. Fragility refers to their ease of damage, probably beyond repair. In contrast, their vulnerability refers to the threat they are put under due to the various alternative uses for which they can be utilized.

As the human population continues to expand day by day greatly, the demand for food production and land also increases, and so does the stress place on wetlands. Therefore, these important ecosystems will continue to decline unless humans intentionally and actively conserve and manage them greatly.

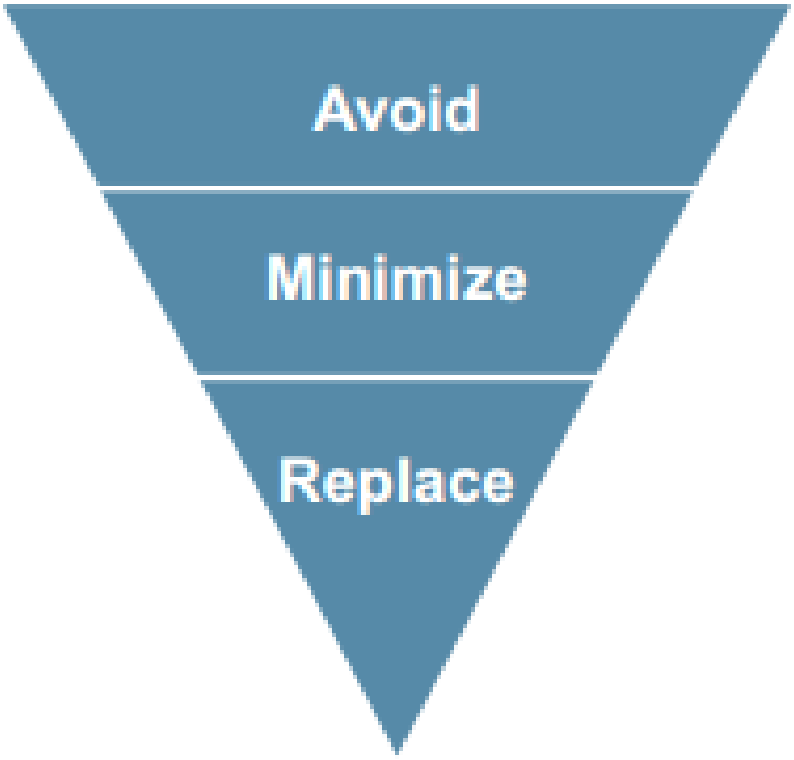
3.1.5 Wetland Loss Mitigation

According to Koning and Ashworth (2019), mitigation of wetlands aims at restoring the ecosystem operation that is compromised and damaged wetland ecosystems. In the mitigation of compromised wetlands, the stages to flow are avoidance, minimization to replacement. Avoidance is the primary response in the mitigation of wetlands. Proponents should avoid impacts such as constructing roads near wetlands, constantly draining water from wetlands, and passing drainage canals through wetlands. Minimization is incorporated whereby the impact can't be avoided altogether. Minimization activities may include reducing pollution by treating waste before emitting it into the surrounding wetlands. Replacement of a wetland ecosystem is the result in the mitigation of a wetland, and it resulted in the wetland being damaged

totally; therefore, no changes can be made. The proponent must prove that impacts can neither be avoided nor minimized. Replacement of a wetland may involve the construction of an artificial one.

Figure 4 below shows the hierarchy of wetland loss mitigation.

Figure 4: Wetlands Loss Mitigation



Source: (Alberta Wetland Policy, 2020: Alberta Government: p.14)

3.1.6 Concept of Land Use

Land is recognized as a key factor for political, economic, and social transformation. From a social perspective, the word 'land' comprises all the qualities and attributes of the earth. Land can be in various physical forms; that include wetlands, plains, valleys, hills, or mountains. Also, it may have numerous kinds of vegetation. Land, explained from an economic point of view, is the natural resource over which people have

particular rights and may be used to gain returns (Njogu and Dietz, 2006). It is a factor of production in economic processes.

Land is viewed as a single resource with several rights, including private, public, and customary, from legal and political viewpoints (The Constitution of Kenya, 2010).

Hence, the function of land is its utilization. The purpose of the land is to provide a specific function or fulfill a particular objective. According to Briassoulis (2001), land use is determined by the specific purpose it serves, such as habitation, food production, material extraction or processing, recreation, or the land's biophysical qualities. This land use is a direct consequence of human utilization of natural resources. This study categorizes land uses adjacent to the wetlands into two main types: rural catchment land use and urban catchment land use.

3.1.6.1 Rural Catchment Land Use

In human geography, a rural catchment area is where a location naturally allures a populace that utilizes its economic opportunities and services, majorly for agricultural purposes.

In rural areas, land use is driven by the following factors: availability of favourable soils, good climate, and water availability for agriculture and food security. Since 1948, the concept of food security has been a topic of global concern. The Universal Declaration of Human Rights, established in that year, declared that every individual has the entitlement to a decent quality of living, which includes access to food, for the purpose of promoting their own well-being and that of their family. In 1966, Article 11 of the International Covenant on Economic, Social, and Cultural Rights further asserted the "right of every individual to be free from hunger." This right is also further categorized as a basic right and recognized as the principal economic right for an individual. Additionally, this worldwide concern intensified following the World Food Conference in 1974, highlighting the decreasing world food supplies and the large-scale food scarcity, triggering responses in the International Community centred on expanding domestic agricultural production.

Agricultural yields vary from food crops that are dorminant such as plantain, cassava, maize, and vegetables, comprising peppers, lettuce, leafy vegetables, tomatoes,

cauliflower, carrots, and cucumbers to livestock such as poultry, goats, cattle, and small ruminants.

Besides farming acting as a catalyst for food security, a large population in the rural areas relies on it for economic gains. Intensive agricultural practices in water catchments often threaten the ecological integrity of the wetland ecosystems. Stressors of water quality, for instance, unsafe ammonia levels and hypoxia resulting from nutrient or organic run-off and increased plant productivity, are noteworthy menaces to freshwater in wetlands. High contamination levels from agricultural activities are present in water catchments; therefore, various management choices are currently being researched. Organic farming is regarded as an important alternative to conciliate water preservation and agricultural activities.

3.1.6.2 Urban Catchment Land Use

In human geography, the urban catchment area is the zone from which a setting such as a city, institution, or industry attracts a populace that utilizes its economic possibilities and services. Additionally, catchment areas can be defined based on where the populace is naturally drawn; for instance, one constructed by an organization or government to avail services to the population or a labour catchment area.

In urban areas, land use is affected by the following factors: population growth, occupation and income levels, encroachment of built-up areas, urban development policies and regulations, physical attributes of an area, affordability of land and construction materials, enforcement of development control, higher property and business taxes, political power, and land use decision-making, vehicular and pedestrian traffic, technology and time frame for approval of development plans (Mwathi, 2016).

The urbanization process during the previous century has had a spatial aspect, too, with rapidly developing urban areas encroaching on the areas that yield high rent and other land uses around them, demanding more urban land.

Current urban water management implementations target expelling wastewater and stormwater efficiently from urban areas. Alternatively, wastewater and stormwater can be utilized as potential resource substitutes for a section of the water sourced through the piping systems.

3.1.7 Implications of Catchment Land Use Activities on Wetlands

Land-use conflicts manifest in the incompatibility of land uses within proximity, i.e., uncoordinated development densities in the urban area and uncontrolled agricultural practice in the rural area. The ecologically fragile areas such as the wetlands, natural water channels, and water basins have been the primary victims of uncontrolled development. Wetlands worldwide are encountering heightened conflicts between the varying water and land uses. Numerous wetlands are overused, and their aptness to meet varying environmental, economic, and social demands is declining. The key deficiency in the wetlands management is figuring out how to turn potential conflicts into positive coordination by integrating urban-rural developments and wetland conservation. The closeness of the populace settlements to wetlands has resulted in man's overexploitation of the wetlands for their needs such as irrigation, domestic uses, transportation, livestock, and urban uses.

3.2 Theoretical Approaches to Wetlands as a Natural Resource

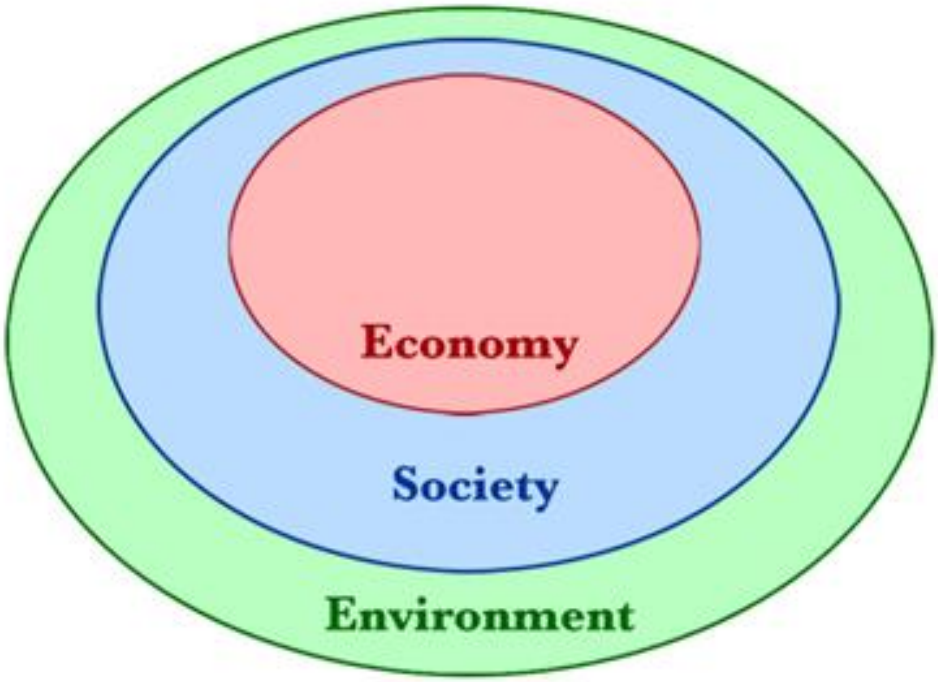
This section discusses key theories and models that can be used to analyze the wetlands as an economic and natural resource base.

3.2.1 Economics of Natural Resources

Natural resource economics concentrates on the earth's natural reserves' demand, supply, and distribution. The primary objective of natural resource economics is to better comprehend the contribution of natural resources to the economy. By scrutinizing natural resources, economists acquire knowledge on how to develop more sustainable approaches to managing resources to guarantee that they are conserved for subsequent generations. Additionally, economists scrutinize the interaction between natural and economic resources in developing an efficient economy.

Natural resource economics relays the interdependence and link between natural and human ecosystems. The centre is how to control an economy within the ecological limitations of the natural resources of the universe.

Figure 5: Interdependence Between the Economy, Society and the Environment



Source: (Introduction to Natural Resource Economics, Boundless Economics, 2020)

Figure 5 exemplifies that the economy and society are subgroups of the environment. Economic and social systems cannot exist singly in the environment. Thus, natural resource economics concentrates on the demand, supply, and distribution of natural resources to improve sustainability.

David Ricardo (1772-1823) believed that the scarcity of natural resources must eventually limit economic growth. In due course, low-grade resources have to be utilized, and the increasing costs will result in a 'stationary state' of output in the subsistence level, population, and wages (Ricardo, 1817). Pigou (1877- 1959) is repeatedly alluded to in the debate on the shortage of natural resources and the inter-generation impacts regarding soil fertility, coral, and fish. He proposed that government intervention is the best approach to safeguard the subsequent generations since present-day persons are likely to be myopic (Pigou, 1929).

Ideally, natural resources are many a time classified into renewable and non-renewable. Renewable resources can self-reproduce or regenerate, for instance, the fish populace.

They can also remain indefinitely productive; however, they may be extinct if overused. On the other hand, the consumption of non-renewable resources by a unit signifies that the stock for subsequent years' consumption is forever decreased. The main challenge the natural resources encounter is inter-temporal distribution. In short, natural resource economics is majorly interested in how much of a stock ought to be intended for utilization today and how much ought to be left in place for the subsequent years.

The standard Nineteenth-Century neoclassical economic model, which shows the decision-making process of a firm's production, presumes that the environment and the economy do not interact. Resources are treated as inexhaustible inputs into the production procedure and any waste generated. However, they may escalate the cost of production by getting rid of them and do not affect the environment. The utilization of nature generates no unique complications for neoclassic economics since, with the increasing shortage of natural resources, their prices increase, prompting the search for more affordable substitutes. It was not till the environmental complications of the 1950s and 1960s and the oil catastrophes of the 1970s that the economic theory acknowledged that the neoclassical perspective was oversimplified and required revision (Jowsey, 2003).

In studying natural resource economics in relation to wetlands, the theory is better placed in guiding and providing sustainable approaches to managing and properly utilizing resources today and guaranteeing that they are conserved for subsequent generations.

3.2.2 Garrett Hardin's Tragedy of the Commons

The tragedy of the commons is an economic issue in which every person has the incentive to use up resources but to the detriment of every other person with no means to exempt anyone from consuming. It was created by asking what would have transpired had every shepherd been allowed to graze their flock on the common field, acting in their self-interest. Ideally, if everyone acts in their own best interests, it ensues harmful overconsumption; all the grass is consumed, to the disadvantage of everyone.

The concept of the tragedy of the commons was made famous by the American ecologist Garrett Hardin (1915-2003), who employed the analogy of herders grazing

their livestock on a common field. Herders grazing their animals when the field is not overcapacity may experience just a few limitations. However, the rational herdsman will endeavour to increase their livestock to increase profits. Logically thinking but not doing so collectively, the benefits of increasing livestock are only to the herdsman, while the costs are shared. The tragedy is that no herder will graze the field in the long run due to overconsumption. This sequence of events is played out in various instances daily, resulting in adverse effects on the earth's resources (Hardin, 1968).

This principle applies to the ever-growing human populace, thereby depleting the earth's natural resources. For instance, deforestation, whereby the overexploitation of the forest cover worldwide has resulted in adverse consequences on the environment. Following the lack of proper management of resources, forests have rapidly disappeared over the preceding century. Overhunting and overfishing have also resulted in animal extinction. Drought has also caused painful deaths as the water in the aquifers is drawn faster than they refill. Global warming is, to some extent, the consequence of a tragedy of common people, as individuals, corporations, and the government fails to regard the cumulative impacts of their actions on the environment.

The consumption and over-utilization of natural resources, including while eyeing short-term gain without conservation leads to depletion of natural resources and climate change.

It is generally recognized that one of the main responsibilities of the government at the international, national, state, and local levels is to define and manage communal resources. However, several practical issues come about with this. Managing distinct political boundaries is straightforward, but resources communal across jurisdictions may be problematic. For instance, neighbouring towns may make the most of the benefits through competition for industry but minimize their cost, on the other hand, by forcing residents off their jurisdiction.

3.2.3 The Value-Belief-Norm Theory of Environmentalism

This theory Stern et al. (1999) connects the value theory, norm activation theory, and the environmental model approach through a causal chain of variables resulting in environmental conduct. It computes from other theories to account for three forms of

non-activist environmentalism: private-sphere behaviour, environmental citizenship, and policy support.

This theory explicitly elaborates on human behaviour and environmental interactions and how these interactions can impact each other. It explains the relationships among norms, beliefs, behaviours, and values in a causal chain.

The value implies the guiding principle of any deed established on desirable trans-situational objectives, which may differ in importance (Schwartz, 1992). Schwartz poses value components related to Altruistic values referring to collective values relating to other people and the living species which inspire individuals; biosphere values which emphasize the biosphere, the environment, and the ecosystem; egoistic values, which means the self–interest concerning the community. This comprises authority, being influential and wealthy. Lastly, openness to change values implies simulation and self-direction established on independent thought and deed, which contradicts the inspiration to fulfil others' expectations.

In applying the Value-Belief-Norm Theory of Environmentalism in the study, the primary concern of users of the land would be on the land use activities causing harm to the wetlands. The policy-making authorities, on their part, would be concerned about the inducements that cause encroachment and degradation of wetland areas. Even though there are regulations and institutions that are authorized and mandated to protect these areas. The preparation of strategies and plans to safeguard the wetland areas would be the primary concern of professionals and experts.

The process by which land users, professionals, policymakers, and public institutions make decisions thus gives rise to significant concerns because the spatial environment that their choices create must encourage the prudent use of wetlands lest they result in their destruction.

3.3 Effects of Rural Catchment Land Use Activities

Agricultural practices are the principal rural land use that has an impact on wetlands. Over time, agricultural activities in the wetlands have altered the physical characteristics of the environment, particularly the quality of water and soil.

Agricultural activities conducted in wetland areas have a dual impact on the surrounding physical environment through drainage and reclamation, with soil playing a crucial role as the physical element. Because of this, the disintegration of soil typically takes place after the shift from natural vegetation to horticulture land. According to Cox and Ashley (2000), the topsoil that is not covered by the natural flora that is removed and the farmland that is furrowed is frequently washed away by rain and blown away by the wind. The disintegration of soil influences profitability because it sweeps the topsoil, which includes a substantial number of natural nutrients, fine soil particles, and plant supplements. These nutrients and supplements are stored in the root area, where they are available to plants. According to Baez et al. (1987), retained subsoils are less productive, less porous, and less able to store pesticides, composts, and other plant supplements.

Another disadvantage to the increased use of pesticides is improving the resistance of vermin species. The solitary rodents that can endure pesticide application continue to breed, eventually producing a population with improved chemical resistance. To effectively manage insect populations, pesticides in this particular form require higher doses or alternative compounds. Consequently, these organic compounds have a high degree of durability in the environment and build up in the tissues of animals, resulting in water contamination, fish mortality, and a decline in other bird species. Due to their high water solubility, certain new herbicides have the potential to impact the groundwater in agricultural areas (Rebelo et al., 2010).

3.4 Effects of Urban Catchment Land Use Activities

Infringement of urban land uses results in effects that decline the value and functions of natural areas. This refers to the development of rails, roads, structures, and utilities into natural areas such as river corridors, ponds, lakes, floodplains, and buffers surrounding these sectors. The word encroachment also comprises the placement of fill, removal of vegetation, or a topography change in such locations. These encroachments result in effects on the functions and values of natural territories, for instance, loss of habitat both terrestrial and aquatic, loss of flood attenuation, disruption of equilibrium state, a decline in water quality and reduction of ecological undertakings.

Encroachment and construction of structures on wetlands are significant land-use undertakings that impact the physical attributes of the environment such as land cover and water. Most destructions on wetlands are immediate consequences of the monetary practices of man. These practices range from agriculture, developmental activities to water redirection, among many others (Ajibola et al., 2012). (Reid et al., 2005) in the Millennium Ecosystem Assessment, the report highlighted that the abjection and loss of inland species and wetlands have been attributed to structural improvements such as reservoirs, levees and dikes, water withdrawals, overharvesting, pollution, change of land usage and the appearance of obstructive outsider species.

3.5 Role of Land Use Planning

Land use resource management involves providing maximal benefits of the resource to the individuals of the present generation who rely on these resources and preserve their potential for subsequent generations. The idea of wise utilization of resources is closely linked to sustainable development. This concept stresses incorporating ecological, social, and economic elements in managing resources (Parikh and Datye, 2003). It entails conserving the ecosystems while ascertaining benefits to the local communities on a long-term basis, particularly the less-advantaged segment of society. Comprehending the wetland and its management affairs guarantees that you regard how to conserve all wetland species and ecological undertakings that maintain the site and aids in incorporating a wetland management plan within the broader scope of environmental management planning.

The management planning procedure ought to develop and effectively communicate an ideal condition, shape, or image for the future of the wetland by first describing the condition required for the wetland. The purpose of describing the wetland is to have its status defined by a range of factors that are considered acceptable and tolerable. Secondly, pinpoint the factors that impact the wetland and consider the features that may alter the wetland as a repercussion. It is essential to identify the direction of change and potential change indicators. Lastly, identifying and quantifying several performance indicators for observing progress is also crucial in meeting the objectives for the wetland.

3.5.1 Optimization of Land Use in Wetlands

Agricultural undertakings have kept endangering wetlands and their biota in the push for economic development. The Ramsar Convention (1991) proclaimed the smart and deliberate use of wetlands for the benefit of the human population in a manner consistent with the preservation of ecosystem natural resources. Therefore, the wise utilization of wetlands will be of service to human interests and simultaneously safeguard natural values. The following four aspects may be usefully considered; productivity which refers to the income or yield per unit resource; stability which refers to the consistent levels of productivity with the presence of small levels of disruptions; such as typical climate variations; sustainability which is the capability of the system to sustain productivity with the presence of a major disruption such as; pest invasion, soil erosion or an unanticipated drought period; and finally equitability which refers to the diffusion aspect of the system and how far agricultural produce are divided in the community.

Therefore, the wise utilization of any wetland may be high in sustainability, equitability, and stability but low in productivity. Natural resources may be governed, handled, and safeguarded by conservationists, the local community, and national policy and decision-makers. Additionally, for the sustainable development of wetlands, strong guidelines must be in place. Thus, both local individuals and large-scale investors are required to utilize wetlands wisely. Also, there is a need for local communities to enhance and make use of wetland resources more sustainably.

3.5.2 Concept of Sustainability in the Use of Land

Land-use suitability analysis is a tool utilized to point out the most befitting areas for positioning future and potential land uses. Suitability approaches facilitate environmental managers to scrutinize the interlinkage of factors, environmental elements, development actions, and location. Analysts can map these interlinkages in different ways. For instance, a map can highlight which land will have the most insignificant negative effects on environmental processes, qualitative forecasts of the environmental influence of proposed developments, and the least promising locations for development proposals. Additionally, private developers and public officers may use these maps for policy setting and decision-making towards land use.

3.6 Sustainability Strategies for Coexistence of Urban and Rural Land Uses

Wetland conservation is concerned with the protection and preservation of wetlands. According to (Jeng, 2016), the details help wetlands live and grow and become stewards of the environment in the process. One of the strategies is to preserve a strip of indigenous vegetation along streams and wetlands. A buffer strip is crucial for strengthening the banks of the wetland, preventing erosion, and enhancing the overall health of the wetland. It is important to apply insecticides and fertilizers in moderation. The author elucidates the potential detrimental impact of the chemicals present in this product on wildlife, aquatic life, and water quality. Additionally, the author advises people residing near wetlands to refrain from using this product. An effective strategy for protecting wetlands is the prevention of the entrance and proliferation of non-native and invasive species of flora and fauna. Typically, non-native organisms obstruct and modify the functioning of wetlands.

Lastly, dumping should be avoided, and the stormwater draining into the wetland should not be polluted. The policy development through a multi-stakeholder consultative process also aspires to ascertain the wise utilization and the sustainable management of wetlands to boost the maintenance of their socio-economic and ecological purposes for the current and subsequent generations.

3.7 Identified Gaps in Theory on Wetlands

The research gaps identified revealed that the wetlands are at a breaking point. These losses are collectively because of user externalities foisted on other stakeholders, the public nature of most wetland services and products, and failed policy interventions owing to inconsistency amid government policies in different sectors, such as the environment, economics, physical planning, and deficient nature of protection.

As a result, the wetlands receive little upkeep, no restoration of deteriorated zones, and no regeneration of lost wetland regions. Furthermore, there is no clear strategy to guide land use and other underlying concerns harming wetlands.

3.8 Policy, Legal and Institutional Framework

The section will focus on the policies, strategies, programs, rules, and regulations that have had an impact on the management of wetland areas and the land uses that are near the wetland areas.

3.8.1 Policy Context of the Study

The policy provides as a foundation for an integrated approach to planning and sustainable management of natural resources in the country. Several policy initiatives are proposed, and it acknowledges the existence of ecosystems that are vulnerable. To do this, it is necessary to incorporate environmentally responsible practices into every aspect of society. Moreover, it promotes the establishment of governance and institutional structures that are robust and secure to strengthen the accomplishment of goals and the objectives of policy.

3.8.1.1 Wetlands Conservation and Management Policy, 2015

The policy aims to ascertain the sustainable management and wise use of wetlands to boost the sustenance of their socio-economic and ecological functions for the current and subsequent generations.

It also intends to strengthen collective ownership of wetlands to encourage their conservation and maintenance. It intends to incorporate indigenous knowledge into decision-making to aid education, research, and awareness. Moreover, its objective is to encourage the sustainable utilization of resources derived from wetlands by communities, with the aim of enhancing the well-being of all local inhabitants who depend on wetlands. Its policy statement emphasizes the necessity of taking measures to ensure wetland conservation and sustainable development, as well as developing and implementing wetland management plans, EIAs, and audits in accordance with EMCA. The Kenyan Government has made notable progress towards formulating this policy and bolstered the formulation of the Kenya Wetlands Atlas (2012), which is responsible for mapping the nation's wetland resources. Also, a master plan to guide feasible and revolutionary actions for the sustainable management and conservation of water catchment areas in Kenya has been formulated. As per UNDP (2012), a national inventory of wetlands to account for and keep records of resources, opportunities, and

challenges was formulated to ensure sustainable management and development is ongoing. Additionally, this policy lives up to the objectives of the National Land Policy, the Constitution, and the draft Environment Policy, 2013.

3.8.1.2 Sessional Paper No. 6 of 1999

This sessional paper discusses the relationship between development and the environment and identifies the environment's major issues. Additionally, this paper prioritizes action, capacity building, and implementation tactics. It states that the overall goal is to incorporate environmental issues into national management and planning initiatives, as well as to provide advice for economically, socially, and environmentally sustainable development (Kenya, 1999).

According to sessional paper No.6 1999, Kenya aspires to seek and adhere to the principles of sustainable development in order to meet the demands of the current generation while conserving the resource base's capacity to meet future generations' requirements. However, the country's present development strategy is centered on land-use activities such as mining, agriculture, ranching, forestry, infrastructure development, water conservation, tourism, human settlements, processing and manufacturing, and infrastructure development. As a result, the government created this sessional paper, which emphasizes broad legislative principles that encourage long-term growth.

3.8.1.3 Sessional Paper No. 3 of 2009 on National Land Policy

This paper was intended to guide Kenya towards equity, efficiency, and sustainability in land usage for the long run posterity and prosperity. It was achieved by discussing and handling issues linked to the degradation of the quality of land, urban squalor, insecurity, squatting and landlessness, and tenure disputes.

This paper was focused on dealing with crucial matters relating to land access, land administration, land use planning, degradation of the environment, disputes, reparation of historical injustices, and unplanned upsurge of informal settlements in urban areas.

The paper categorizes Kenyan land into private, community, or public land, safeguarding customary land rights. It also acknowledges and protects private property rights and provides derivative rights from all types of land rights holding.

By approving the sessional paper, the government will ascertain that all land is utilized productively and sustainably by promoting the enactment of crucial principles on land use, conservation, guidelines, and productivity targets.

Additionally, the government will champion a multi-disciplinary approach to land use, avail economic and social incentives, and provide a conducive environment for possible investment in agricultural activities, exploitation of natural resources, and livestock rearing.

To ensure that land-based resource management is sustainable and sound, conservation and sustainable land usage will be steered by principles highlighted in the government laws and policies.

Land management and administration issues will be handled by strengthening and streamlining mapping and survey systems, land allocation and registration systems, adjudication processes and procedures, and land markets.

The policy mandates the government to develop and implement state protocols for improving the depth of land records via information tech methods like computing at both the national and local levels. Such aims to solve the limitations encountered in planning, zoning, and all that entails land oversight. Such will feature georeferencing, pre-requisites for Land Management Systems, intellectual property rights, budgeting, and disseminating land.

Such a policy aimed at proving a skeleton of policies and regulations tailored towards upholding an administrative framework for managing land to avail public opportunities for accessing and beneficially occupying and using the land. Additionally, it is to provide economically sound, socially just, and environmentally ideal land usage, along with efficient and cost-effective functioning of land markets. Lastly, it offers practical and clear-cut land dispute resolution approaches.

3.8.1.4 Kenya National Spatial Plan 2015-2045

The formulation of this plan was recommended as a prominent effort within Kenya Vision 2030. The goal of this initiative is to provide a comprehensive framework for the efficient and sustainable utilization of national space. The plan provides policies and initiatives to tackle national deficiencies in areas such as regional disparities,

environmental degradation, urbanization, transportation, and underutilization of abundant national resources.

The policy plan establishes a spatial framework upon which the different sector policies and programs will be constructed. The organization formulates physical planning methods to facilitate economic and sectoral planning, as well as to provide guidance for regional, county, and local development plans. The goals of this initiative are to create a spatial planning framework that improves economic efficiency and strengthens Kenya's global competitiveness, to promote logical regional development for national unity and coherence, to optimize the utilization of land and natural resources for sustainable progress, to establish livable and functional human settlements in urban and rural areas, and ultimately, to protect the natural environment for a higher quality of life.

The plan also aims to promote active participation from the public, create dense urban areas, implement intelligent and environmentally friendly urban growth to enhance well-being and visual appeal, and achieve sustainable development for economic success, quality of life, and effectiveness.

3.8.1.5 Sessional Paper No. 1 of 2017 on National Land Use Policy

This policy was developed by the Ministry of Lands and Physical Planning to guide Kenya to a socially and environmentally responsible utilization of land and its resources for the socio-economic change of the population of Kenya. It was formulated under social responsibility, cultural conservation, economic productivity, and environmental sustainability.

It aimed to encourage best practices for the maximum use of land resources equitable, efficient, sustainable, and productive at the community, county, and national levels. The policy is vital in addressing matters on land and land-related resource utilization by providing guidelines and principles for; Land use planning to boost sustainable development, advancing environmental conservation and preservation, anchoring land development initiatives, land and land-related disputes, and the Classification of land uses in the country.

To address issues related to land cover, land use planning, and land use data, the policy calls for the development of land use plans at both national and county levels which shall be informed by comprehensive participation of stakeholders who shall ensure strict adherence to the plans.

The policy calls for mapping and documenting all land uses in the nation and creating a framework incentive that will boost forest cover land banking for agricultural, commercial, residential, industrial, and infrastructure development.

3.8.2 Legal Context of the Study

There are several policies and laws that provide guidelines on the management and conservation of natural resources in Kenya. The main ones include the Constitution (2010) and the Environmental Management and Coordination Act,1999 (Amended in 2015).

3.8.2.1 The Constitution (2010)

The Constitution of Kenya, 2010, makes provisions for the right to a clean and healthy environment and outlines the responsibilities of the State and individuals in ensuring sustainable exploitation, utilization, management, and conservation of the environment and natural resources for the benefit of the people of Kenya. Article 69(1)(a)] outlines the obligations of the State in respect of the environment: The State shall "ensure sustainable exploitation, utilisation, management and conservation of the environment and natural resources, and ensure the equitable sharing of the accruing benefits."

The principle of sustainable development has been established in the Constitution Article 10(2)(d) as one of the national values as governance principles.

Sound conversation and protection of ESAs is provided for I Article 60(1)(e). Article 60(1)(e) states “sound conservation and protection of ecologically sensitive areas.”

3.8.2.2 Environmental Management and Coordination Act,1999(Amended in 2015)

The Act provides safeguards on wetland and wetland resources management. Additionally, it highlights certain principles to vouch for sustainable management and use of resources.

The Minister is authorized to issue broad and detailed directives, criteria, or rules for the management of wetlands and those that are at risk of environmental degradation. Additionally, it grants the County Environment Committee the authority to assist communities in the sustainable management and preservation of services and resources for aesthetic, ecological, and socio-economic objectives.

Section 31 of the Act allows for establishing a National Environmental Complaints Committee (NECC). Their functions include investigating any allegations and complaints concerning the condition of the environment.

NEMA has also operationalized EMCA 1999 by developing subsidiary regulations, including Biodiversity Regulations 2007, Waste Management Regulations 2006, Water Quality Regulations 2006, EIA/EA Regulations 2003, and Wetland Regulations 2009.

3.8.2.3 Forest Conservation and Management Act, 2016

Facilitates the administration of water catchment areas by focusing on soil and water preservation, carbon storage, and other ecological benefits through cooperation with appropriate stakeholders.

Section 22 requires the Kenya Forestry Research Institute to promote development programs and research in order to generate information and technology for the sustainable development of forestry and related natural resources.

County governments are required by Section 37 to compel real estate developers to establish green zones that cover at least five percent of the total land area of each planned housing estate.

According to Section 42, indigenous forests and woodlands must be managed in a sustainable manner to protect the soil, biodiversity, water, shoreline, and riparian areas. This management should also promote tourism, recreation, education, and research. Additionally, it should support cultural use and heritage, carbon sequestration, provide

habitat for fisheries in mangrove forests, support wildlife in terrestrial forests, and ensure the sustainable production of wood and non-wood products.

3.8.2.4 The Land Act No. 6 of 2012

This Act implements Article 68 of the Constitution by amending, consolidating, and rationalizing land-related laws to enable the sustainable administration and management of land-based resources, land, and associated purposes.

The Act provides equitable access to land, sustainable and high-yielding management of land resources, security of land rights, cost-effective and transparent land administration, eradication of gender discriminative customs, laws and affiliated practices to land and property inland.

The Act also empowers the National Land Commission to develop guidelines for the long-term conservation of land-based natural resources.

3.8.2.5 The Water Act, 2016

The Water Act regulates the utilization, administration, supervision, and preservation of water resources. The document focuses on the utilization, possession, and governance concerns related to water resources, along with safeguarding the regions where water is collected. The establishment of an institutional structure aims to aid communities and the public in effectively managing water resources in catchment regions (GoK, 2012). Urban areas serve as a paradigmatic institutional framework for community engagement, encompassing inducements for efficient water utilization, a well-coordinated infrastructure for water supply and sanitation services, and the incorporation of environmental factors into water management strategies.

The Act establishes the Water Resources Authority (WRA) as the authorized body of the National Government in charge of overseeing the control and utilization of water resources.

3.8.2.6 Kenya Water Tower Agency Order, 2012

The Kenya Water Tower Agency was established by the government under Legal Notice to coordinate and monitor water tower protection, rehabilitation, conservation,

and management efforts. The agency is also mandated to recover and restore degraded water towers, wetlands, and biodiversity hotspots in collaboration with relevant institutions.

3.8.2.7 Water Quality Regulations, 2006

The goal of the regulation is to forbid discharge of influence into the environment contrary to the set standards. The laws provide standards and guidelines for releasing toxins, radioactive waste, poisons, or other pollutants into the atmosphere. Every individual shall avoid any activities that directly or indirectly result in water pollution, whether the water body was polluted, before the legislation of the Environmental Management and Coordination Act (EMCA), 1999.

Section 6 (c) of the law states that no one shall till or engage in any development activity within six meters and thirty meters of the greatest ever recorded flood level on each side of the river, stream, or waterbody.

3.8.2.8 County Government Act No. 17 of 2012

Article 6 of the First Schedule of the Kenyan Constitution (Kenya, 2010a) highlight the need of distributing national resources and functions to all forty-seven counties, promoting decentralization and devolution.

According to the County Government Act (Kenya, 2012c), county planning shall encompass spatial and environmental planning, along with other aspects. Furthermore, planning principles should encompass the interests and needs of future generations. They are required to synchronize and protect natural resources in accordance with the policies set out by the national and county governments in sections 102 and 103.

This Act, passed by Parliament, protects specific areas and zones designated for the protection of groundwater, as specified in the recently approved Constitution. County governments play a crucial role in improving the management of water resources under their jurisdiction.

3.8.2.9 Physical Planning Act (CAP 286)

This Act provides for the control of any developments. Under the approved physical development plan, it mandates the local authorities to manage, maintain, and preserve all the land designated for parks, green belts, open spaces, and urban forests.

3.8.2.10 The Crops Act, 2013

Section I (3), by encouraging the production, processing, marketing, and distribution of crops in the appropriate regions of the nation, this Act seeks to: accelerate the development and growth of agriculture generally; improve agricultural productivity; enhance the investment climate; improve the efficiency of agribusiness; raise the incomes of farmers and the local populace; and cultivate crops as export crops that will boost the nation's foreign exchange earnings.

3.8.2.11 Irrigation Act, 2019 (No. 14 of 2019)

An Act of Parliament allows for the advancement, regulation, and management of irrigation to enable sustainability in food security and socio-economic development in Kenya. An inhabitant of a water catchment area who engages in either livestock keeping, crop farming, fishing, or small local industrial activity or uses water for irrigation from a common water source, together with other inhabitants, may all come together to form an irrigation water users' association. In instances where an association is formed before an irrigation scheme, the association may be acknowledged as the bona fide association to maintain and oversee the scheme formulated in the association's area of coverage. Additionally, more than one association can manage a scheme on pertinent and mutually agreed-on terms. The Act also stipulates mechanisms for conflict resolution.

3.8.2.12 Agriculture Act (Cap. 318)

An Act of Parliament to maintain and advance good agricultural practices, provide for soil conservation and fertility, and encourage agricultural land development abiding by the approved principles and practices of good husbandry and land management.

3.8.2.13 Agriculture (Farm Forestry) Rules,2009

Protects shorelines, riverbanks, wetlands, and riparian areas. The rules also outlaw growing or maintaining any Eucalyptus tree species in riparian or wetland areas. It also contains provisions on enforcement measures and inspection.

3.8.2.14 The Urban Areas and Cities Act, 2011

An act of Parliament establishing the framework for instituting urban areas, allowing for the management, government, and classification of cities and urban areas, as well as the principles of participation, resident involvement, and related elements, is needed to put Article 184 of the Constitution into effect.

3.8.3 International Treaties, Conventions and Multilateral Environment Agreements (MEAs)

This section explores the international treaties, conventions, and Multilateral Environment Agreements (MEAs) that have influenced the management of wetlands.

3.8.3.1 The Ramsar Convention

According to Davidson (2018), the Ramsar Convention is an international treaty on the sustainable use of wetlands. This treaty is named after Ramsar, a city in Iran, where the signing of the convention took place on 2nd February 1971. The Ramsar Convention, as earlier stated, provides a somewhat broad definition of wetlands to the international community. Also, it plays a role in conserving the sustainable use of wetlands, acknowledging the fundamental ecological role of wetlands' economic, cultural, scientific, and recreational value.

A Ramsar Site is a wetland site designated to be of international importance. This treaty covers approximately 1916 internationally recognized wetlands. These wetlands are in over one hundred and sixty nations and cover roughly an area of 462 million Acres. These areas covered by wetlands contextually can be compared to Switzerland, Germany, France, and Spain's surface area.

On 5th October 1990, the convention came into effect in Kenya. Presently, Kenya has six sites deemed Wetlands of International importance (Ramsar Sites). The wetlands cover an area of 265,449 hectares.

The Mission of the Ramsar Convention is "Conservation and wise use of all wetlands through local and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world." To achieve this Mission, the vital ecosystem functions and services that they avail to the nature and human populace must be fully acknowledged, sustained, restored, and wisely utilized through the national planning process, establishing natural reserves on wetlands and prioritizing capacity building wetland research and management.

3.8.3.2 Framework Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC, 1992) obligates parties to consider the deliberations on climate change to a feasible extent. It stresses the importance of incorporating the considerations of appropriate environmental, economic, or social activities and policies and encouraging the application of suitable methods, such as formulation and national review of impact assessments, to reduce detrimental effects on public health, the economy, and the status of the environment. Wetlands, including Ondiri wetland, play an essential role in storing carbon micro-climate associated with climate change. Also, it serves as a water storage system, particularly for use in the dry season.

3.8.3.3 Sustainable Development Goals

Sustainable Development Goals were ratified by the United Nations in 2015 and acknowledges that the actions in one area affect the outcomes of other regions; therefore, development ought to balance economic, social, and environmental sustainability.

3.8.3.4 African Eurasian Water Bird Agreement (AEWA)

This is an agreement that Kenya is party to and calls for the coordinated and concerted action by states within the migratory routes to protect migratory water bird species and their habitats.

3.9 Summary of the Theoretical Background

The definitions of wetlands as per the Ramsar Convention on Wetlands clearly reveal Ondiri as a wetland as it is a natural area with a peatland and freshwater flowing out of it.

The chapter has also highlighted the importance of wetlands. On the other hand, the chapter has also demonstrated that wetland areas are plagued by several problems because of constitutive variables. The application of the findings of research studies to address the difficulties that are now being faced by wetlands has been brought to light by a review of the relevant literature.

The findings are then utilized in the process of formulating policies, which are utilized during the implementation, monitoring and evaluation, and management phases to accomplish the prudent utilization of wetland areas.

3.10 Conceptual Framework

The conceptual framework entails the elements and factors that play a part in influencing the state of the wetland. This study assesses the cause-and-effect relationship between the urban and rural land use activities (independent variable) on the state of the wetland (dependent variable).

However, intervention or mediation variables also play a role in influencing the relationship between the independent and dependent variables. Policy and Institutional frameworks are intervention variables and are essential as they guide Professionals and Land Users. Policies and institutions determine land use, types of developments and activities, and densities. Policy and institutional environments also influence the types of guidelines used in fulfilling roles, as well as the perceptions and behaviour of public officers, land users, and land development experts. Kenya's national and county governments must effectively formulate and implement applicable policies, as well as

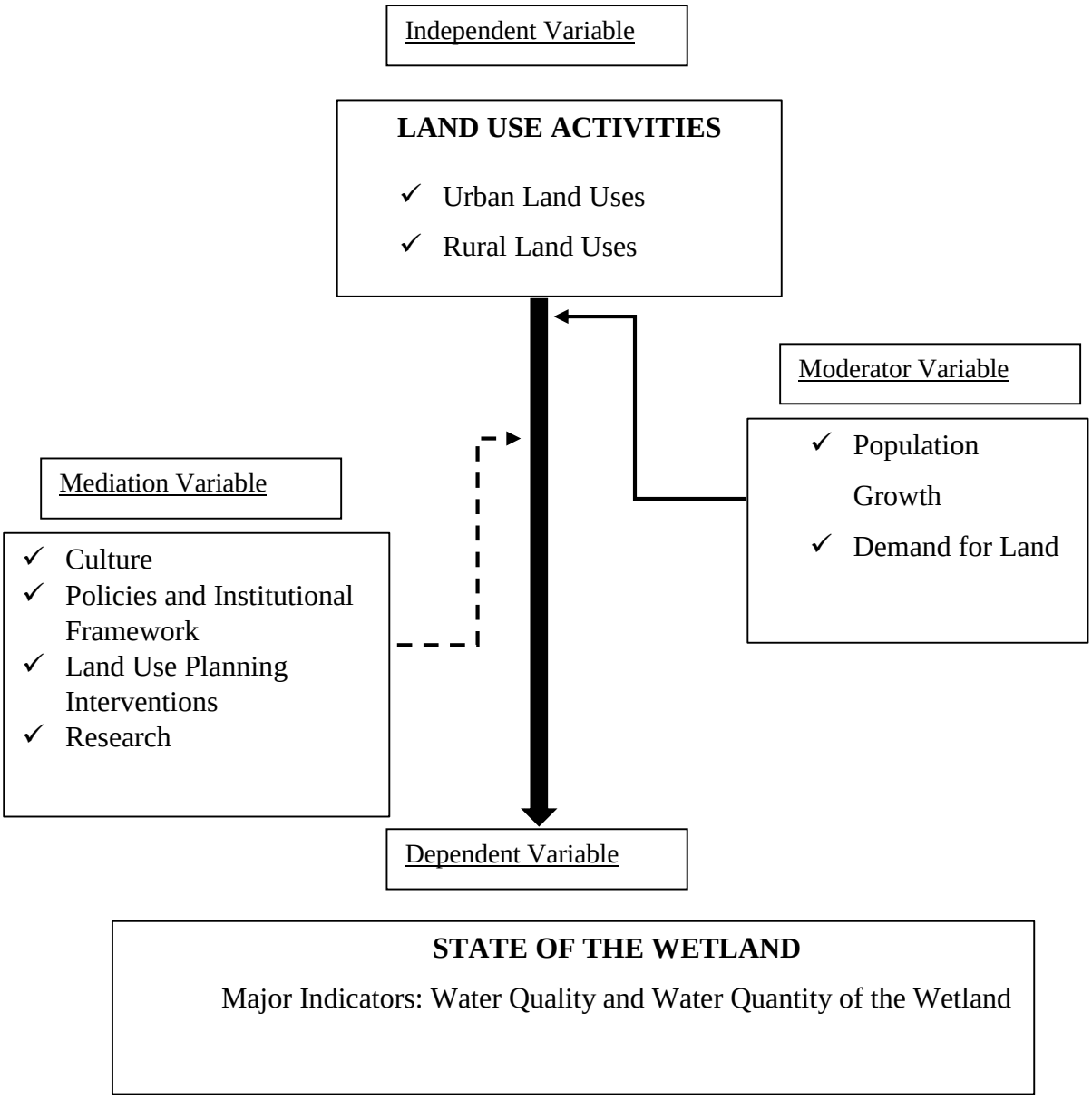
monitor and evaluate them, to promote proper land use and environmental management institutions.

Another variable intervention is the factors that influence the wetland's survival, development, and evolution. These are the ecological properties, and they include vegetation cover, slopes, and soils. They have implications for the conservation of the wetland.

Lastly, another factor is the socio-economic factor, defined as the external factors or moderator variables influencing land-use changes. They include population changes and demand for land for different uses. They have implications for the dynamics of the wetland ecosystem.

Figure 6 below illustrates the flow of the conceptual framework.

Figure 6: Conceptual Framework



Source: (Author, 2022)

CHAPTER FOUR: STUDY AREA

4.0 Introduction

This chapter entails a review of the history and describes the Ondiri Swamp study area to understand better the geographical area. The chapter is characterized by geographic location within the national, regional sub-county, ward, and local contexts. In addition, the climate, topography, drainage, influential human factors including demographic dynamics, socio-economic and cultural profiles of the study area are also covered.

4.1 Brief History

Ondiri Swamp derived its name from the local community. A narration from a local legend has it that it was initially an open lake that could be seen from as far as its surface used to shine in the early part of the 19th century. The locals used to call it ‘Kahenia,' which means to shine. With the settlement of the white settlers in the area, they called it Old Lake, which was changed to ‘Ondiri’ by the local community. However, as deforestation and subsequent erosion progressed, the lake came to be covered with floating reeds on peat such that now it has an extensive reed mat that covers the wetland to form a quacking bog. The surface shakes when you walk over it as the vegetation carpet is only a few feet thick and overlies a water body.

The wetland has, however, been classified and referred to as a swamp contrary to its current state which brings it out as a bog as revealed in the classification of wetlands in the literature review section.

It is the only highland bog in Kenya and the largest quaking bog in East Africa. It is also the second deepest wetland in Africa after Doula in Cameroon (FOWCON, 2009).

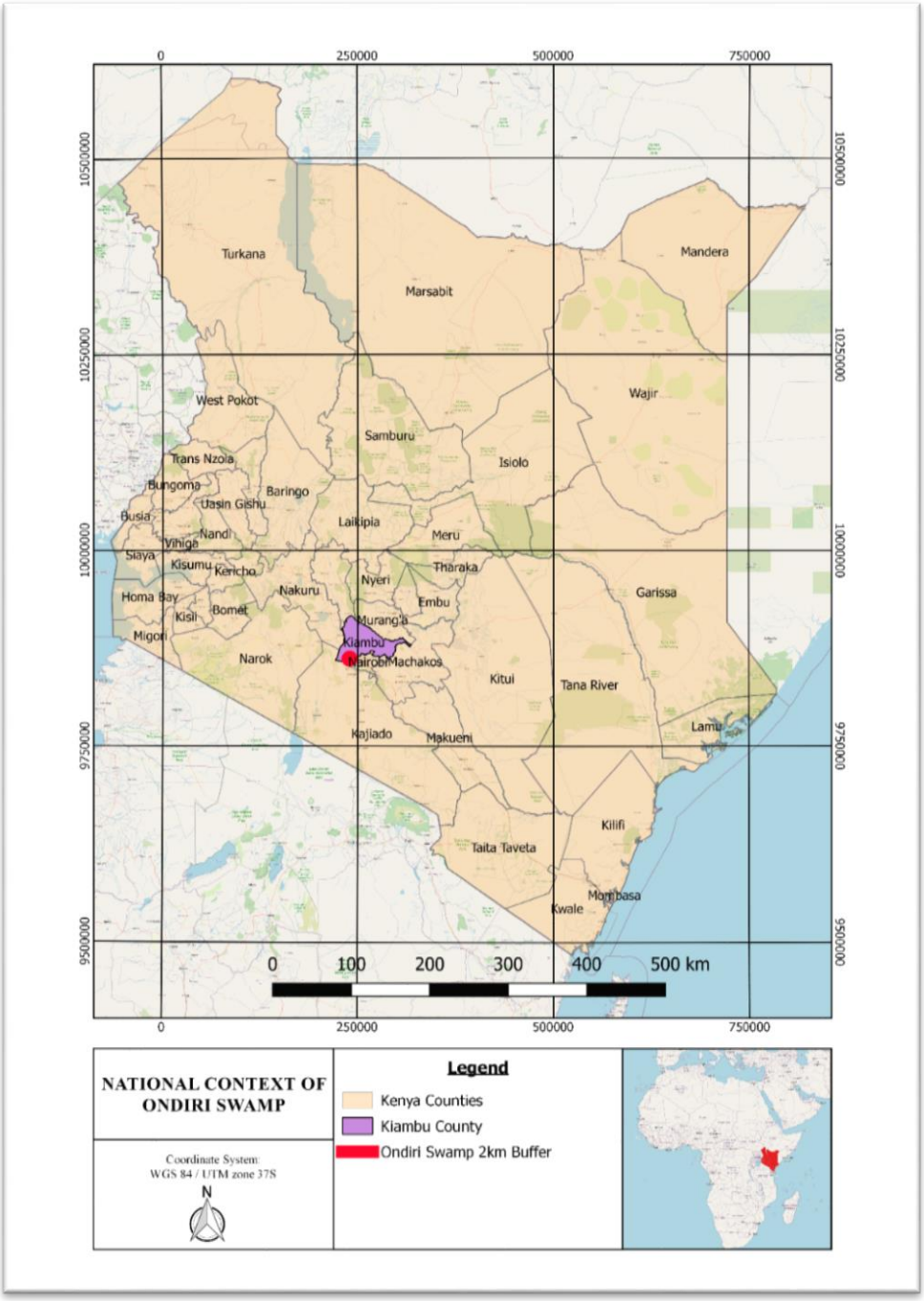
4.2 Geographical Location

Using the Geographic Coordinate System (GCS) to describe the location of the study area, Ondiri Swamp lies at longitude 36.658362°and latitude -1.249338°.

4.2.1 National Setting

Ondiri Swamp is in Kenya which lies in the Eastern part of Africa. Kenya shares borders with South Sudan and Ethiopia to the North, Somalia and the Indian Ocean to the East, Tanzania to the South and Lake Victoria and Uganda to the West. Figure 7 depicts the location of Ondiri Swamp within the Kenya's National Setting.

Figure 7:National Context of Ondiri Swamp

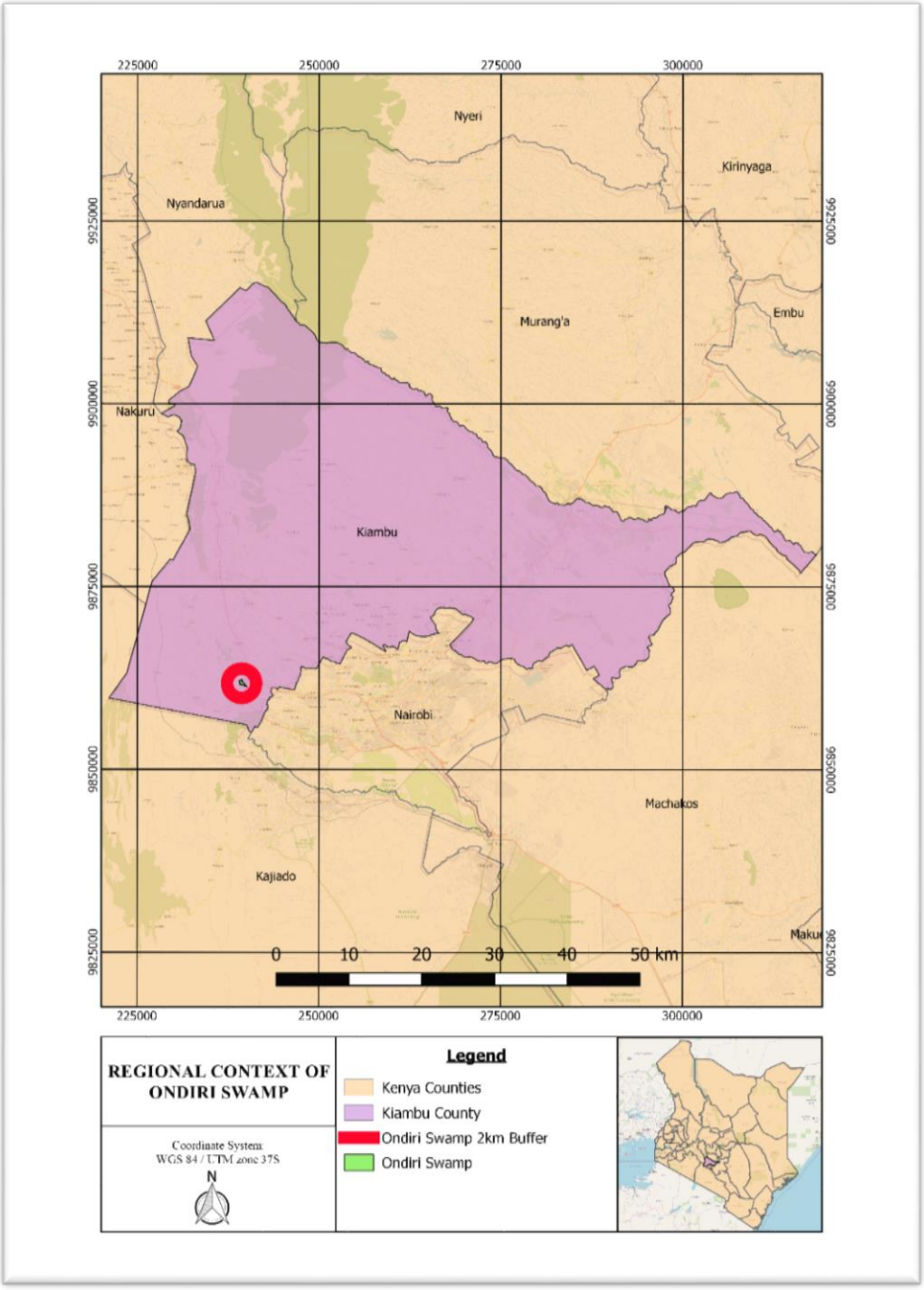


Source: Author,2022

4.2.2 Regional Context

Ondiri Swamp is in Kiambu County. Kiambu County borders Nairobi and Kajiado Counties to the South, Machakos to the East, Murang'a to the North and North East, Nyandarua to the North West, and Nakuru to the West. Figure 8 depicts the location of Ondiri Swamp within Kiambu County.

Figure 8:Regional Context of Ondiri Swamp

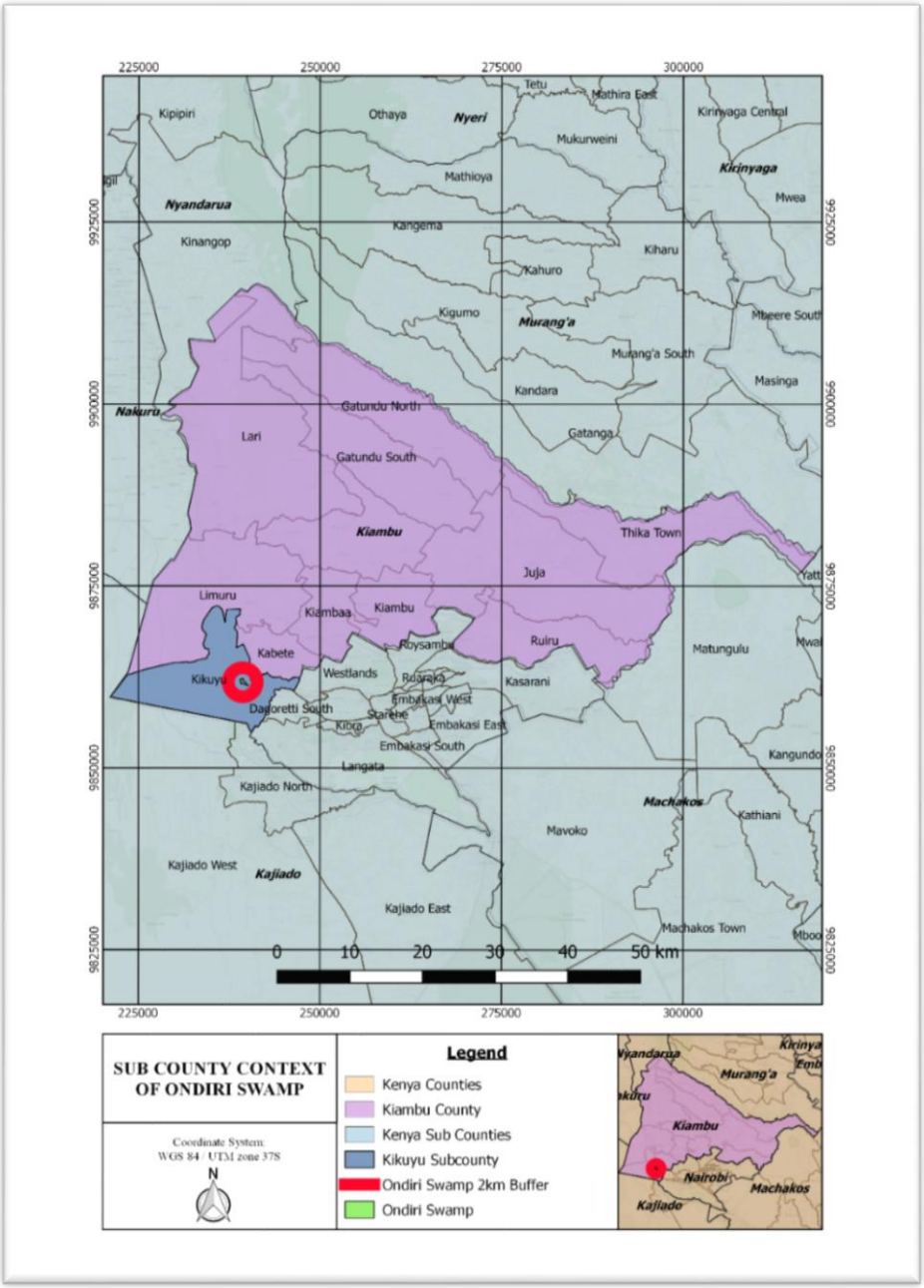


Source: Author,2022

4.2.3 Sub-County Context

Ondiri Swamp is located within Kikuyu Sub-County in the southwestern part of Kiambu County. Kikuyu Sub-County borders Limuru Sub-County to the North, Kabete Sub-County to the East, Kajiado West and North Sub-Counties in Kajiado County to the South, Westlands and Dagorretti South Sub-Counties in Nairobi County to the East. Figure 9 depicts the location of Ondiri Swamp within Kikuyu Sub-County.

Figure 9:Sub-County Context of Ondiri Swamp

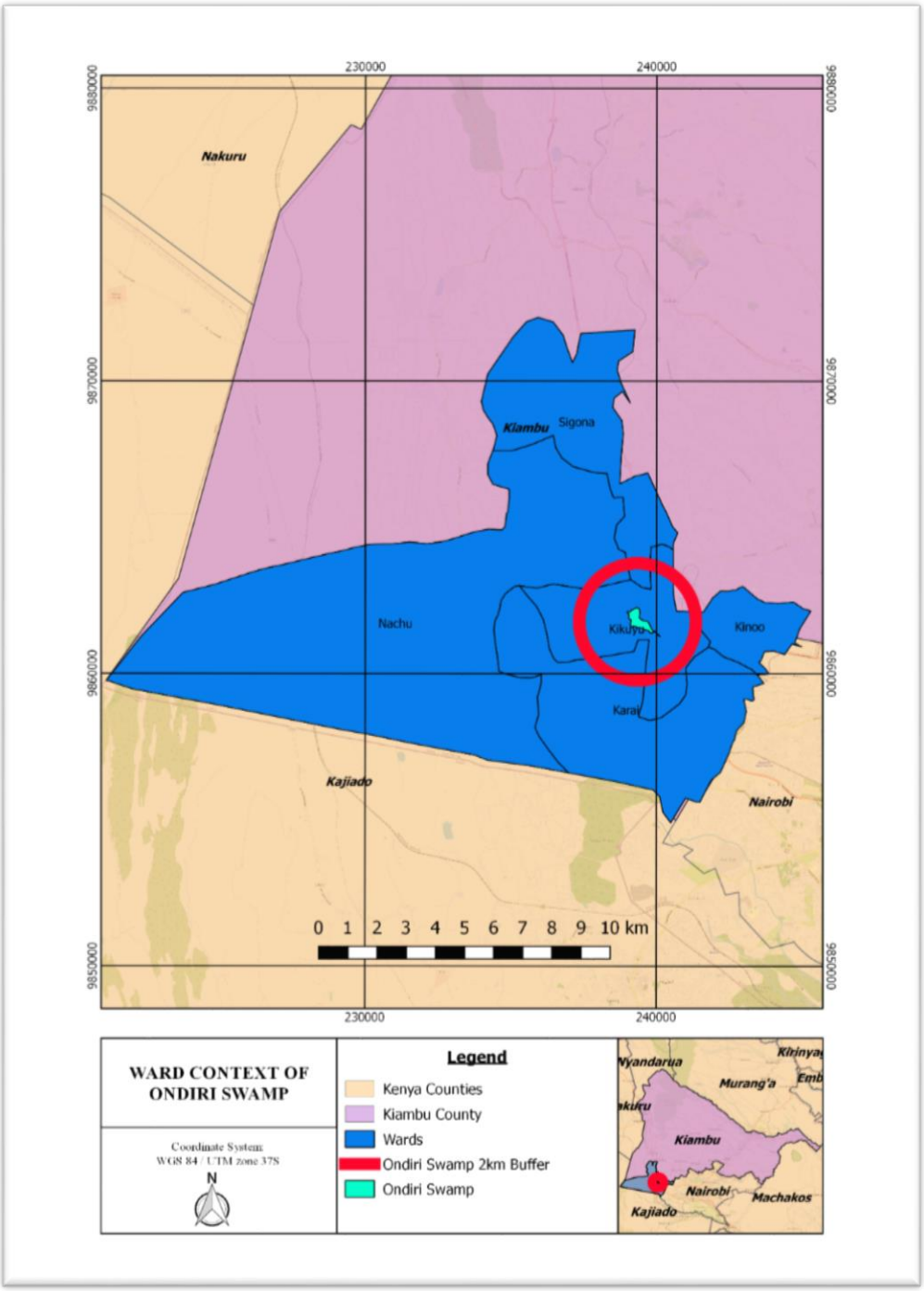


Source: Author,2022

4.2.4 Ward Context

Ondiri Swamp is in Kikuyu Ward. Kikuyu ward borders Sigona and Nachu to the North, Karai to the South and Kinoo to the East. Figure 10 shows Ondiri Swamp within Kikuyu Ward.

Figure 10: Ward Context of Ondiri Swamp



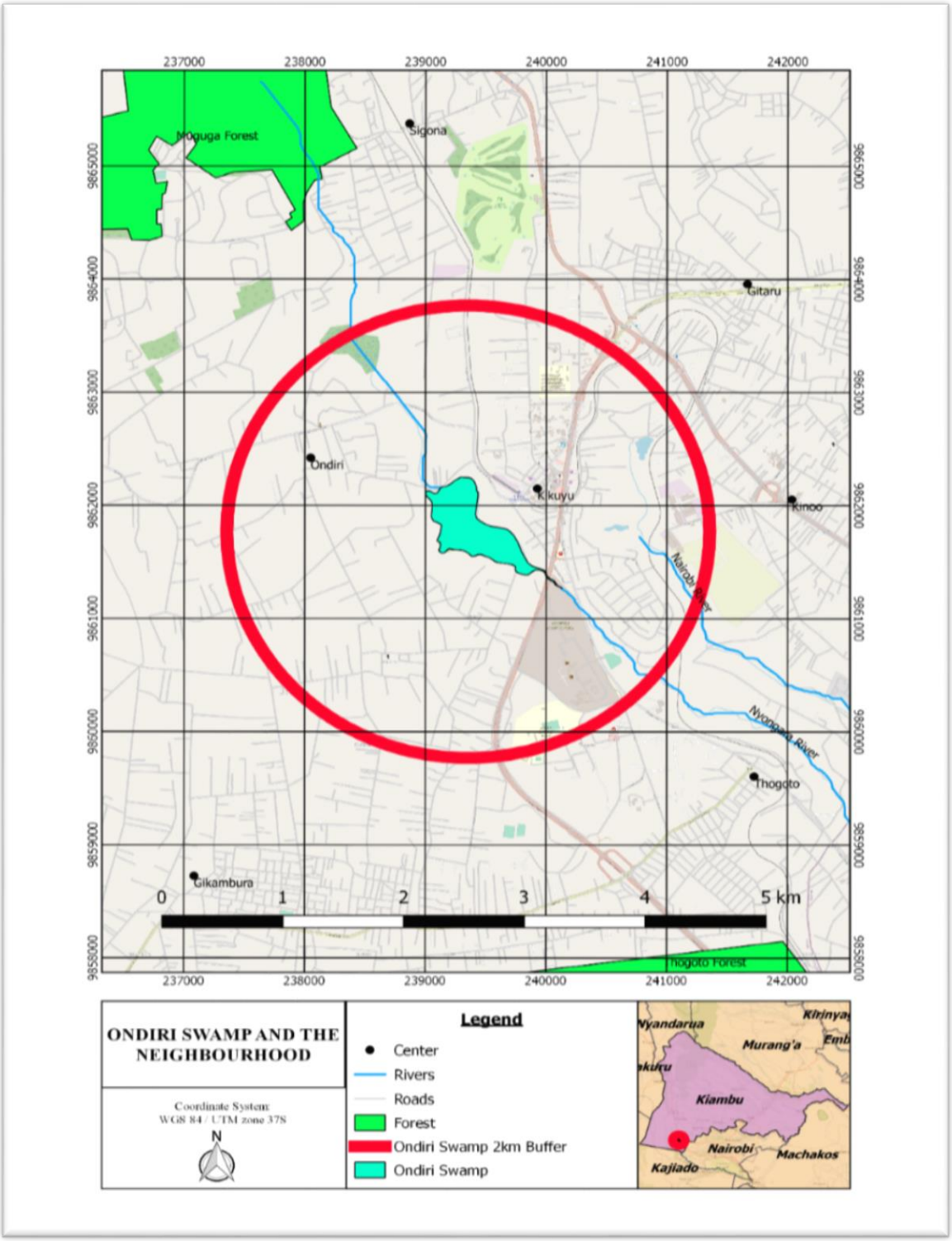
Source: Author,2022

4.2.5 Ondiri Swamp Neighbourhood Context

Ondiri Swamp is a unique palustrine wetland located 200 meters south of Kikuyu town, within Kikuyu sub-county, Kiambu County. Kikuyu town is located in the southwestern portion of Kiambu County. It is considered part of the Nairobi Metropolitan Region (NMR) and is approximately 20 kilometres Northwest of Nairobi. Kikuyu is one of the indigenous towns that developed from the settlement of the colonialist missionaries. The presence of a Railway Station played a significant role in the growth of the town. The town also derives water from the wetland. The wetland also serves as a hub for intensive agricultural activities within the rural side adjacent to the wetland.

The mapped location of Ondiri Swamp and its environs is displayed in Figure 11.

Figure 11: Ondiri Swamp and the Neighbourhood



Source: Author,2022

4.2.6 **Ondiri Swamp**

Ondiri Swamp is an Environmentally Sensitive Area (ESA) due to its natural characteristics, landscape form, historical value and also because of the many benefits it presents to the people around it and downstream.

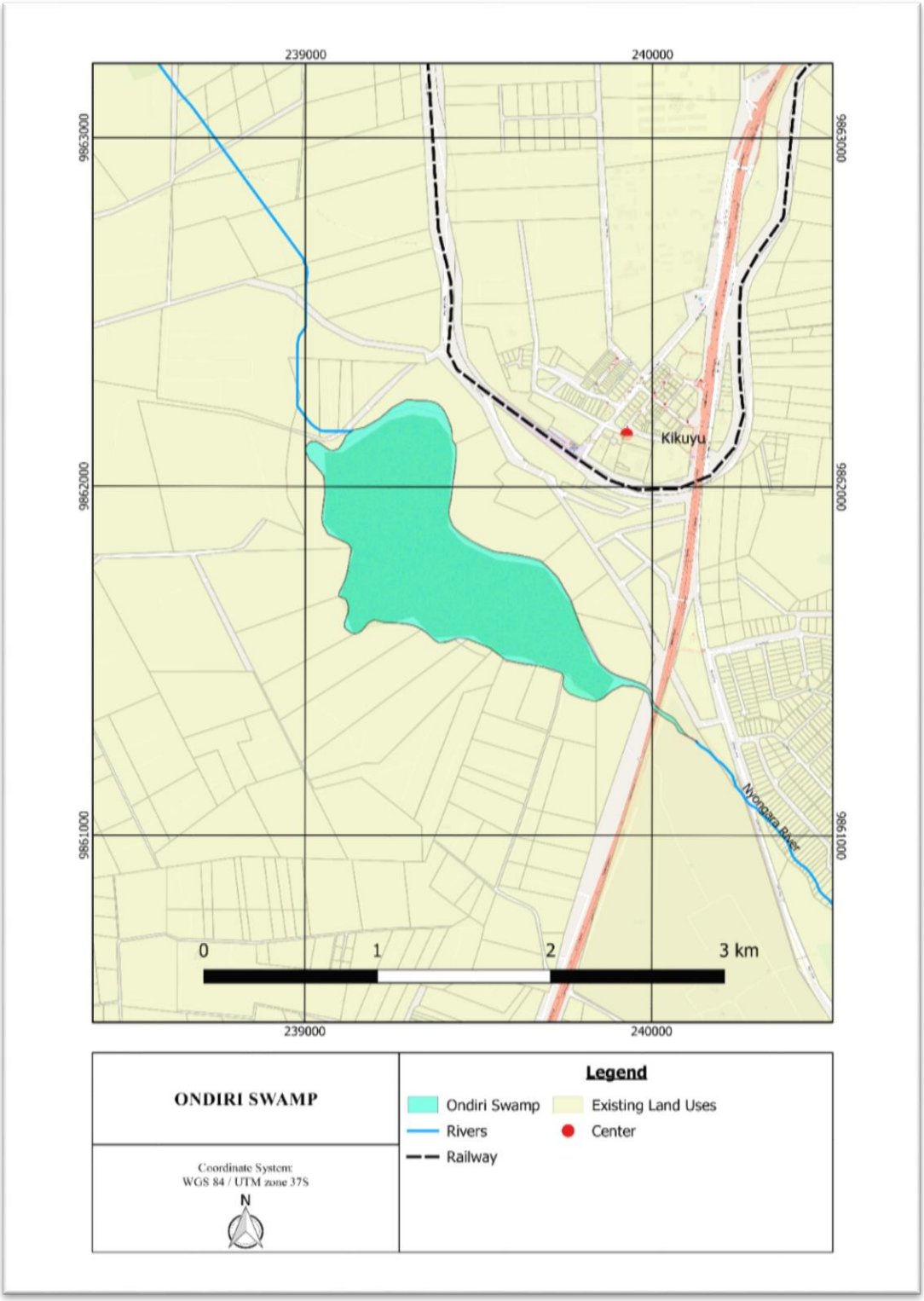
However, the extent of Ondiri Swamp has never been accurately determined. This study, nonetheless, capitalized on georeferencing existing survey plans and resulted in mapping out the boundary as defined by all the abutting parcels adjoining the wetland. The survey plans utillized in the mapping out exercise are attached in Appendix 7.

From the boundary derived from the survey plans, the Ondiri Swamp extends to over roughly 33.3 Hectares with a perimeter of approximately 3.64 km.

The adjoining land around Ondiri Swamp is dominantly urban land uses from Kikuyu Town on the Northern and Eastern sides and rural land uses on the Southern and Western sides.

The outline of Ondiri Swamp derived from the georeferencing and digitizing of the survey plans is displayed in Figure 12.

Figure 12: Outline of Ondiri Swamp



Source: Author,2022

4.3 Climate

The high altitude highly influences the climate. The area has an average temperature of 26° C, which lies between 24°C in the upper highlands and 34°C in the midlands of Karai in the Kikuyu sub-county. The highest temperatures are experienced in January, February and March while low temperatures are encountered in June and July.

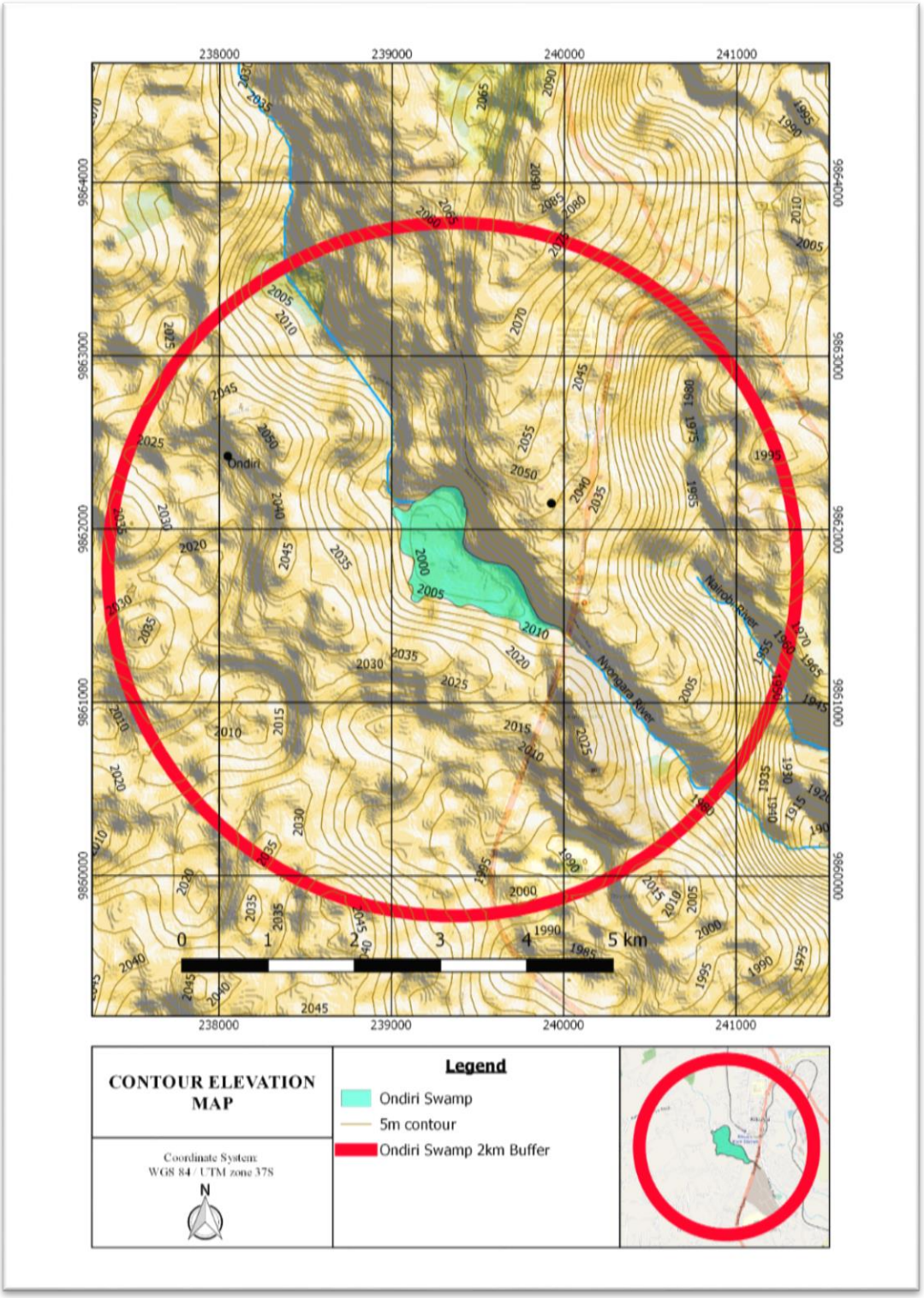
Rainfall is experienced in two seasons; long rains in April and May, while short rains are experienced during October and November. The average rainfall is 1500mm.

4.4 Topography

Kikuyu Sub County, where the Ondiri Swamp is situated, is characterized by high-level structural plains, hills, and plateaus. The swamp lies 2,000m above sea level and an average of 40 m below the general topography of Kikuyu Town.

Figure 13 shows the surrounding terrain's characteristics as well as the elevation of Ondiri Swamp.

Figure 13: Elevation Map of Ondiri Swamp



Source: Author,2022

The swamp is recharged by three rivers originating from the Muguga Forest block, rainfall, and runoff from adjacent areas. However, most of the wetlands' water is recharged through underground seepage from the outer margins of the Aberdare Forest.

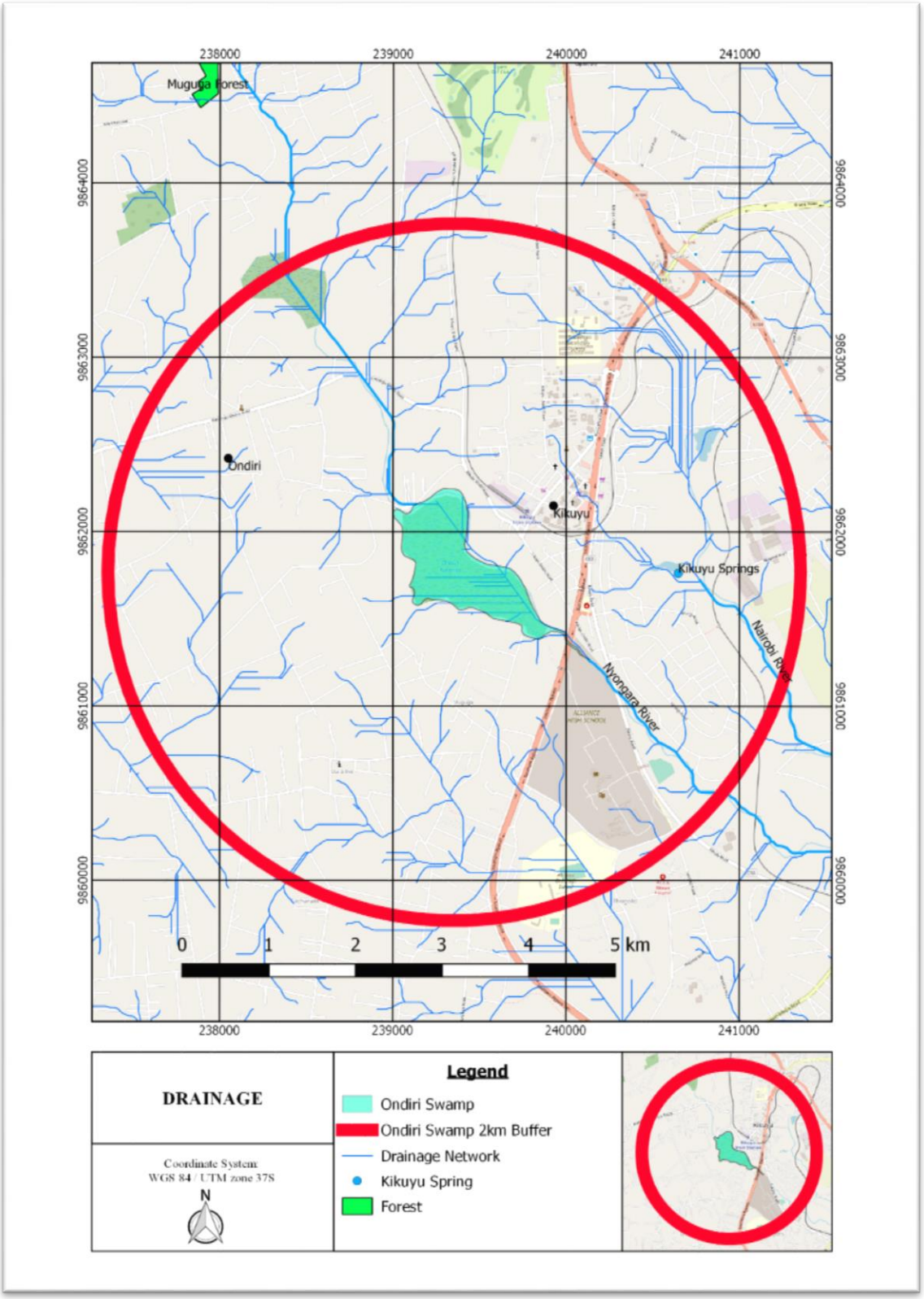
Ondiri Swamp forms the headwaters of the Nairobi River, a tributary of the Athi River then forms the Athi drainage basin. The swamp formed due to tectonic depression, as is familiar on the lower slopes of the Nyandarua-Aberdare ranges (Gichuki, 1998). The depression where the wetland lies resulted from reversed faulting during and following the formation of the Rift Valley (Nyamweru, 1992).

The Ondiri Swamp forms a portion of the Lari-Ondiri fault drainage system. River Nyongara is one of four rivers that trace their origin from the Ondiri wetland. Also, the wetland is alleged to be the source of four underground streams, namely, Kikuyu Springs, Kabuthi, Mbagathi, and Rungiri. The main direction water flows out of the wetland is to the east and south, while some small streams merge to form larger streams downstream that become the headwaters of the Nairobi River. The water body is connected to Kikuyu Springs via an underground passage. This spring is a primary source of Nairobi's water, providing 2% of its water to the City of Nairobi all year round. Therefore, it serves as the primary water source for Kikuyu and its environments, including farms, households, industries, and institutions such as the University of Nairobi, Kikuyu Hospital, and Alliance High School. The spring is also under 24-hour surveillance by the Administration Police.

To the south of Ondiri wetland, the headwaters of the Athi River are formed. Following the underground passage via Thogoto forest, it resurfaces at Karinde close to Karen Estate, where locals refer to Gitwe Kia Mbagathi (headwater of Mbagathi). On the other end, to the southeast, the waters of Ondiri the Nyongara River is formed, which then traverses through the highly populated areas of Thogoto, Dagoretti market, Waithaka, Uthiru, and Kawangware, eventually draining into the Nairobi River at Waithaka.

The catchment area's drainage system is depicted in Figure 14.

Figure 14: Drainage System of The Catchment Area



Source: Author,2022

The soil around the wetland is volcanic type. They are extremely deep, well-drained, red or grey to dark brown friable clay. Soil nutrients in the area support agricultural activities, especially horticultural crops.

The area is a distinctive wetland with macrophytes budding on floating peat roughly 0.5m thick above the water. A total of 68 plant species (Aquatic and semi-aquatic) have been found within the ecosystem. The common species include Typha Domingensis, Vossia Cuspidate, Cyperus Brevifolius, and grasses such as Leersia Hexandra, Eragrostis Exasperate, and Eriochloa Meyerana. The swamp catchment is covered by trees which include the following species: Warbugia Ugadensis, Prunus Africana, Podocarpus Milanjianus, Acaccia Melanoxylon, Acacia Mearnsii, Ocotea Usambarensis, Croton Megalocarpus, Brachylaena Huillensis, Calodendrum Capense, Tecla Nobilis, Strychnos Henningssi, and Diospyros Abyssinia. The common exotic tree species include Grivvellia Robusta, Jacaranda Mimosifolia, Cupressus Lusitanica, and Eucalyptus Globulus (Macharia and Thenya, 2007).

Several diatom species, including algae, have also been recorded in the wetland due to eutrophication. This suggests that the amount of phosphorus, nitrogen, and other plant nutrients in the wetland has gradually increased.

Over 70 Resident and migratory bird species have also been recorded. These species include Cattle Egret, Sacred Ibis, Hadada Ibis, Kingfishers, Hammer Korp, Jackson's widow, Grey Crown cranes, and African Marsh Harrier (Muhati,2002). The Marabou stork also visits the swamp rarely. Ondiri Wetland provides a breeding site for these birds and is classified as an Important Bird Area (IBA).

The wetland also plays a significant role in carbon storage and the control of greenhouse emissions. This helps in climate change mitigation. Also, the soil is largely anaerobic; thus, carbon tucked away into the soil gradually decomposes and can remain persistent for hundreds or even thousands of years.

4.5 Influential Human Factors

The influential human factors covered in this section include demographic dynamics and the socio-economic or cultural profiles.

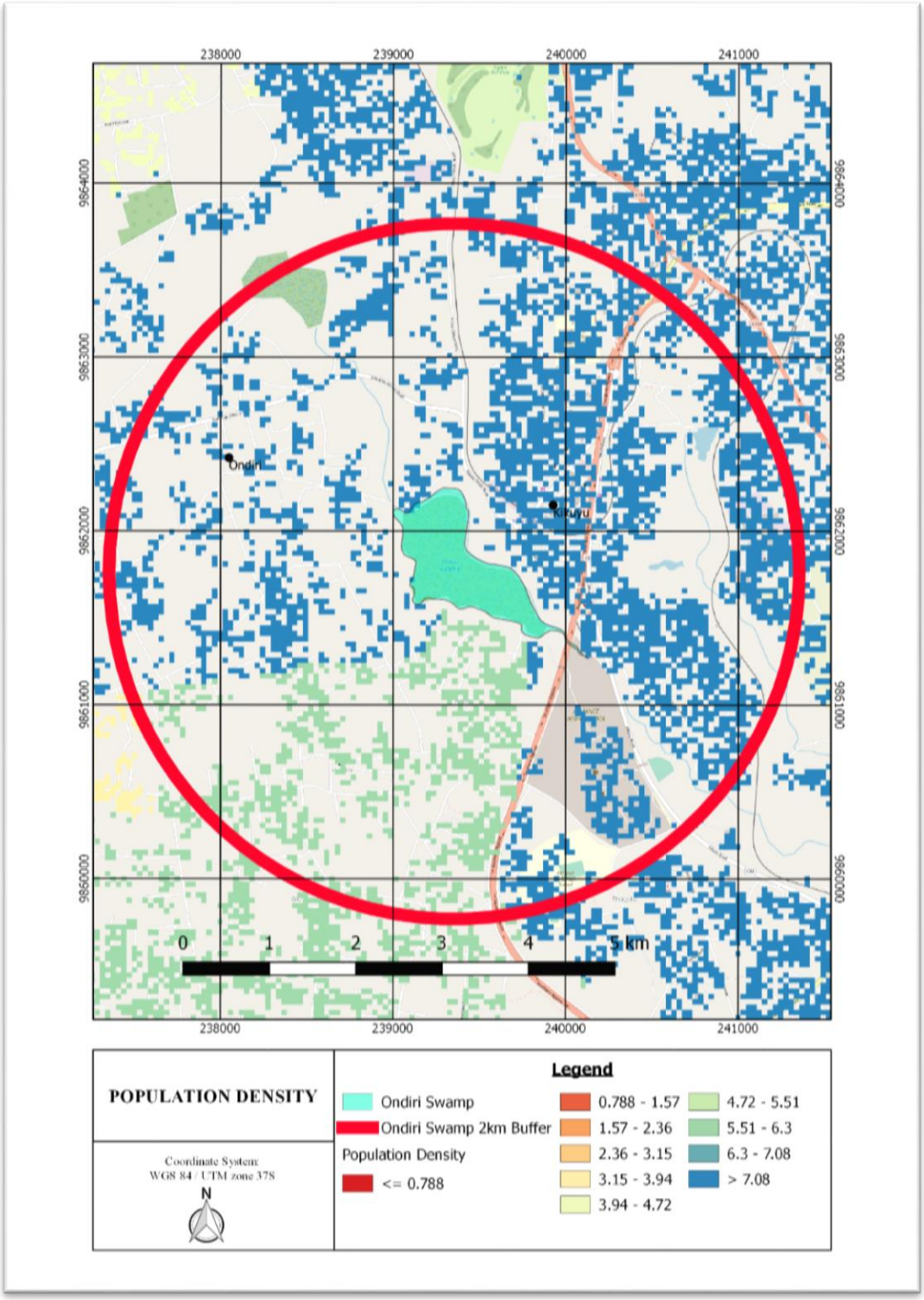
4.5.1 Demographic Dynamics

Ondiri Wetland is situated in a densely populated area, with current figures amounting to 1,186 individuals per square kilometre. Kikuyu is the second-fastest-growing town in Kiambu County and the seventh-most urbanized town in Kenya. This is after Nairobi, Mombasa, Nakuru, Ruiru, Eldoret and Kisumu. Having witnessed tremendous urbanization in the last few decades with people moving in to settle, set up businesses, and other development activities spurred by the devolved systems of Government. As per the 2009 National Population Census, the inhabitants of Kikuyu were 130,370 and 135,459 male and female, respectively, giving a total of 265,829 (GoK, 2010). According to the 2019 Census, Kikuyu has 323,881 persons with 157,008 males and 166 855 females (2019 KPHC). Thereby, from 2009 to 2019, Kikuyu's population has rapidly grown.

Additionally, the area bordering the wetland has one of the ever-increasing populations in Kiambu County owing to Kikuyu town's urban influence, the presence of cloth-making industries, milk production and steel rolling factories, the presence of water that attracts immigrant workers, and rich soils for agriculture. The fast-growing population in this area and the lack of monitoring of human activities in the area have resulted in increased stress on Ondiri Wetland to a degree of compromising the life-long management of the wetland as a powerhouse for ecosystem services and products (Crafter, 1992).

The population distribution around Ondiri Swamp is depicted in Figure 15.

Figure 15:Population Density Map



Source: Author,2022

4.5.2 Socio-Economic/Cultural Profiles

Like any other wetland across the globe, Ondiri wetland is highly regarded owing to its values and functions. The benefits of wetlands, also referred to as ‘services’ can be generally categorized as per functions (flood control, biodiversity maintenance, supporting and groundwater recharge), uses or products (building materials, fish, wildlife products and agricultural produce) that bolster economic attributes and activities (aesthetic values, religious or cultural significance) that support cultural and social activities.

Agricultural practice around the wetland is common due to the rich fertile soils and water availability from the wetland. Crops grown include tomatoes, cabbages, tomatoes, spinach, and kales. It also supports dairy farming as Napier grass is planted near the wetland, and the grass forming the peat is harvested for animal consumption.

Several industries, slaughterhouses, business premises, and horticultural industries depend on the swamp for water requirements.

The unique ecosystem also attracts local and international tourists for bird watching and its status as Kenya's only quaking bog. Many environmental, social, and cultural events have been held near the swamp as it is also used as a recreational site.

CHAPTER FIVE: DATA ANALYSIS AND RESULTS

5.0 Introduction

This chapter presents the results, interpretations, and discussions of the central findings of this study with the aim of addressing key objectives. The objectives were to find out the rural and urban land use activities affecting the wetland, the factors contributing as a result of the rural and urban land use activities affecting the wetland and finally, the land use planning interventions that promote the wise use and the conservation of the wetland.

5.1 General Description of the Sample

The study interviewed a total of 100 respondents. A total of 50 respondents were sampled in the rural area and the rest of the 50 respondents were sampled in the urban area deemed to be majorly within Kikuyu Town.

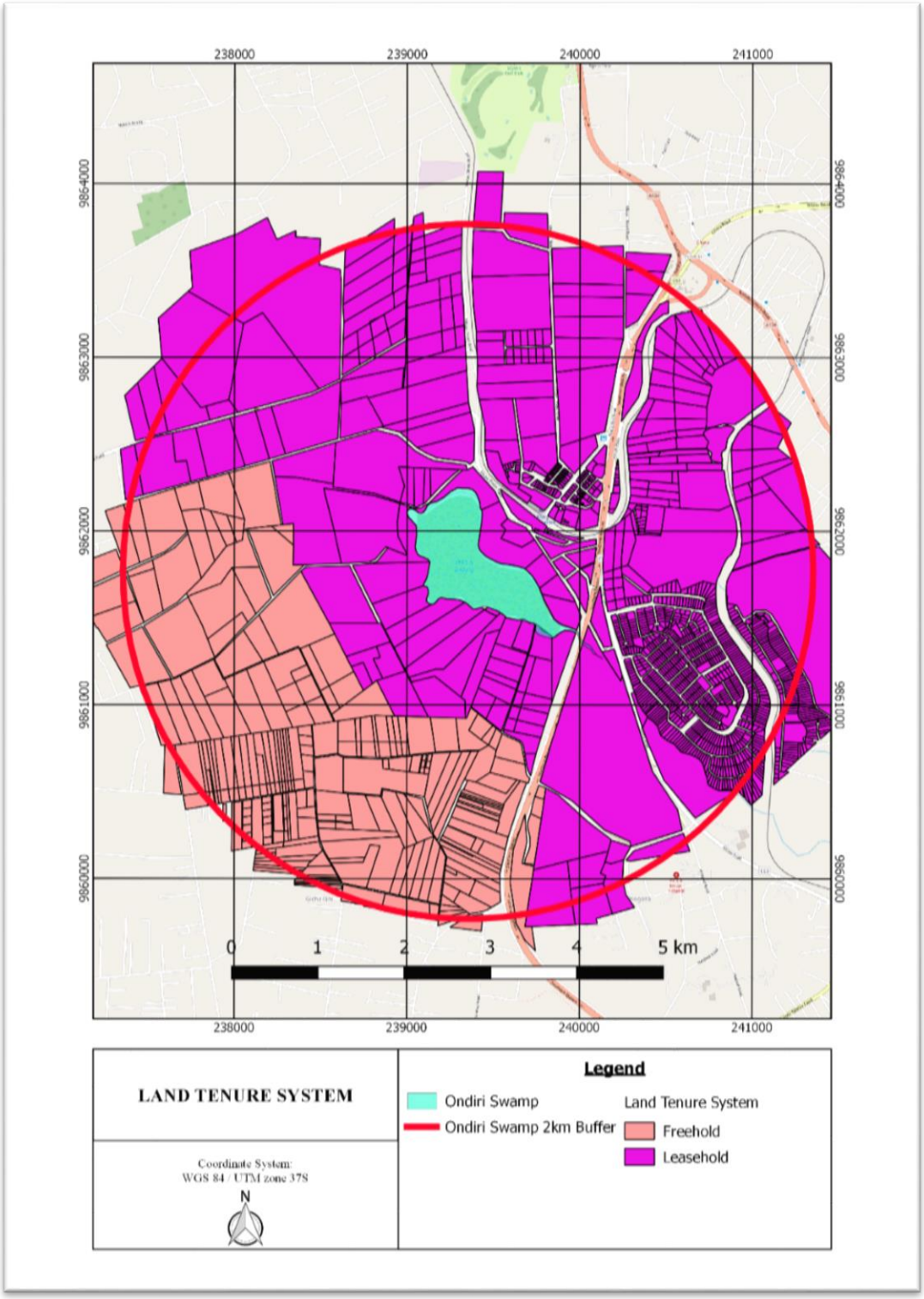
Within the rural side, 56 % of the respondents were male while 44 percent were female. The average age of the respondents was 48 years of age. The average household size was 5. The main source of income amongst the respondents was from Agriculture. The study found that 65 % of the respondents had an acre of land and above, which was the most common land size for households in the rural area. Only 8 percent of the respondents had more than 4 Acres. The study also found that the current average land size is 1.8 Acres.

Within the urban side, 48% of the respondents were male while 52 percent were female. The average age of the respondents was 36 years of age. The average household size was 3. The study found that 82 % of the respondents had an eighth of an acre of land, which was the most common land size for households in the urban area. Only 10 percent of the respondents had more than 1 Acre.

5.2 Land Tenure in the Study Area

This research established that the most prevalent land tenure in the study area is the leasehold at 83% whereas the freehold covers 16%, especially within the rural side as shown in Figure 16.

Figure 16: Land Tenure System

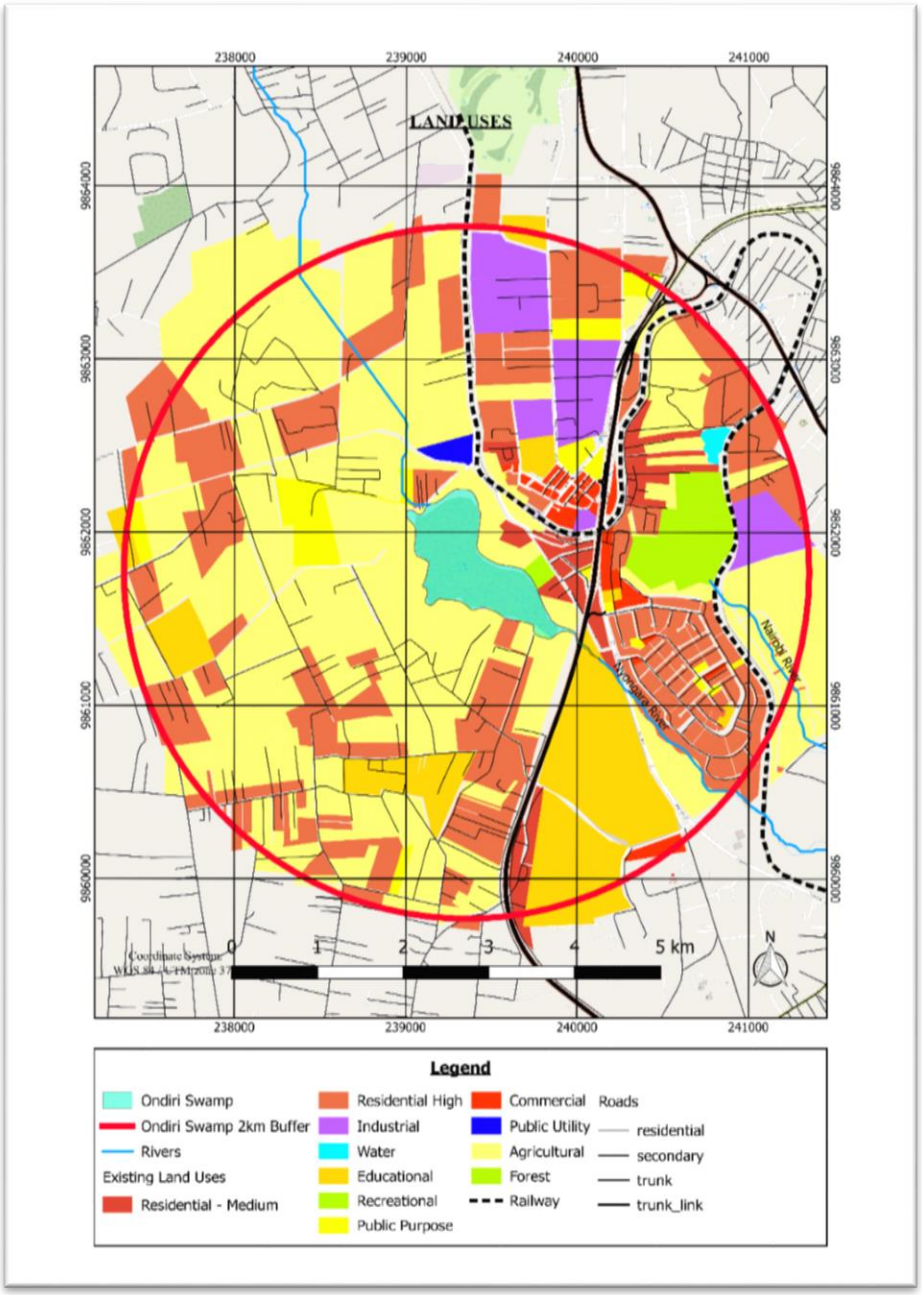


Source: Author,2022

5.3 Land Use Types in the Study Area

The two major land uses in the study area are agricultural and residential land uses. However, commercial, educational, industrial, recreational, public purpose and public utility land uses exist in the study area. Figure 17 depicts the existing land uses in the study area.

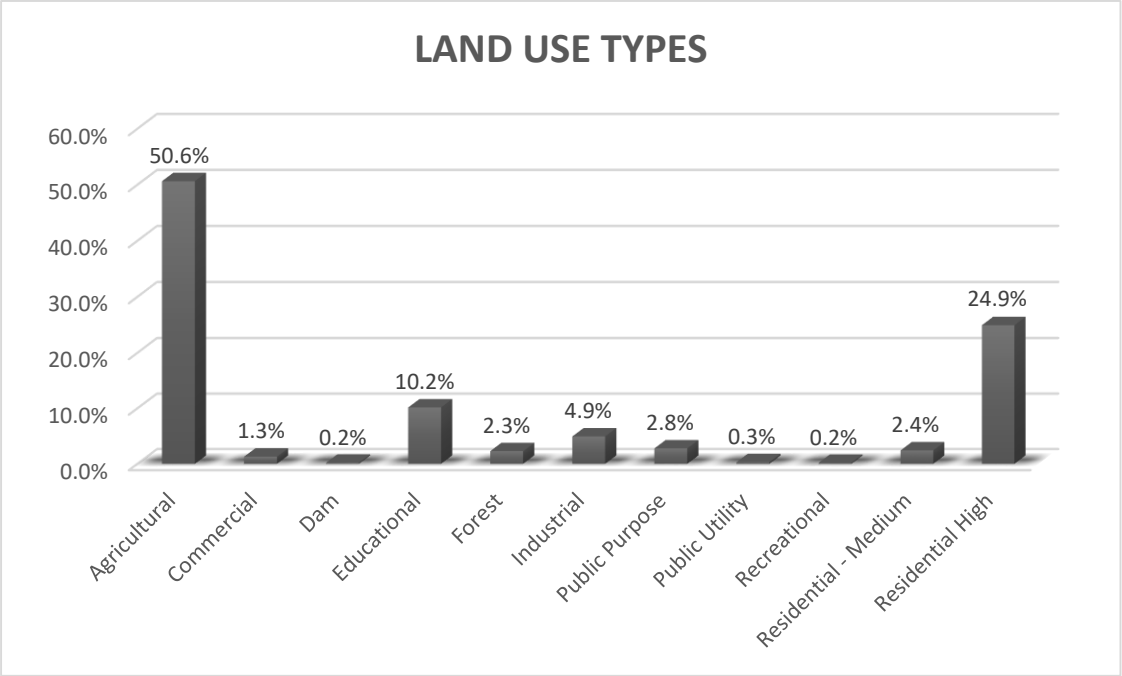
Figure 17: Existing Land Uses in the Study Area



Source: Author,2022

The study reveals the area as an agricultural zone covering 50.6% and a portion of 24.9% is occupied by high residential land use. Educational land use also covers a significant 10.2%. The distribution of the land use types is shown in Figure 18.

Figure 18: Land Use Distribution



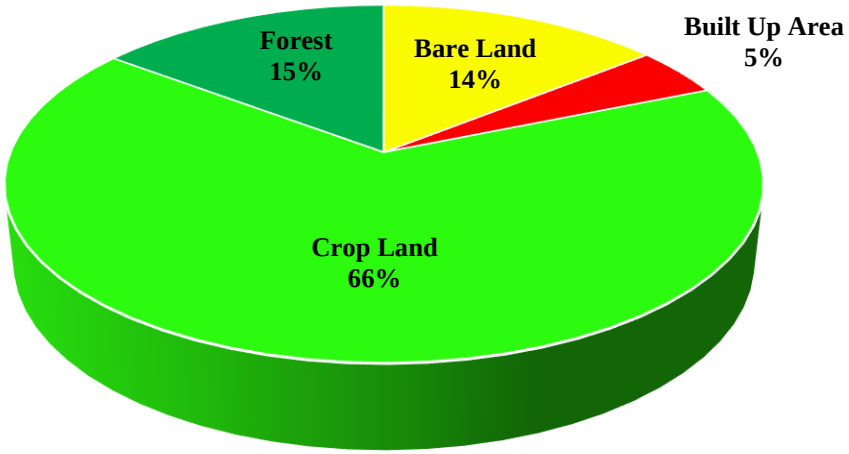
Source: Author,2022

5.4 Land Cover Analysis in the Study Area

Land Use and Land Cover (LULC) around the swamp's 2km buffer area in the year 2002 showed annual cropland as the major LULC covering 66% whereas Bare Land covered 14%. Forest Land covered 15 % with most forest cover found within farmland. The built-up area covered 5%.

Figure 19 shows the distribution of land cover in the year 2002.

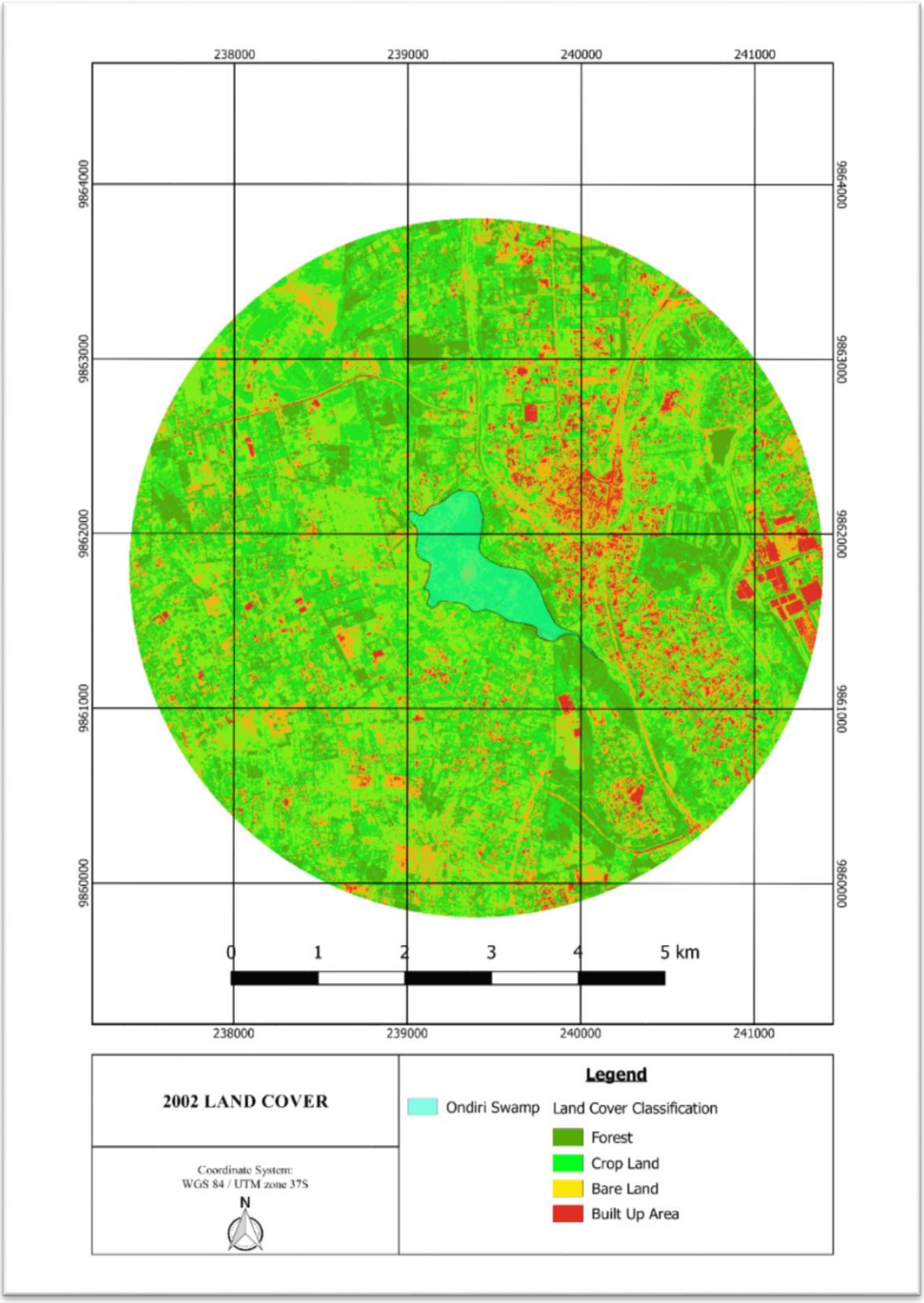
Figure 19: Land Cover Distribution in 2002



Source: (Author, 2022)

The land cover classification for the year 2002 is displayed in Figure 20.

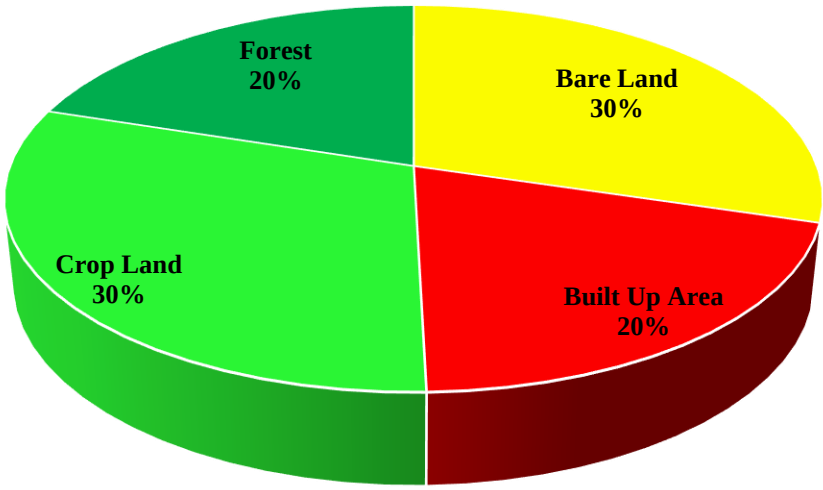
Figure 20: Land Cover in 2002



Source: Author,2022

In the year 2022, annual cropland was the major LULC covering 30% whereas Bare Land covered 30%. Forest Land covered 20% and the Built-up area covered 20%. Figure 21 shows the distribution of land cover in the year 2022.

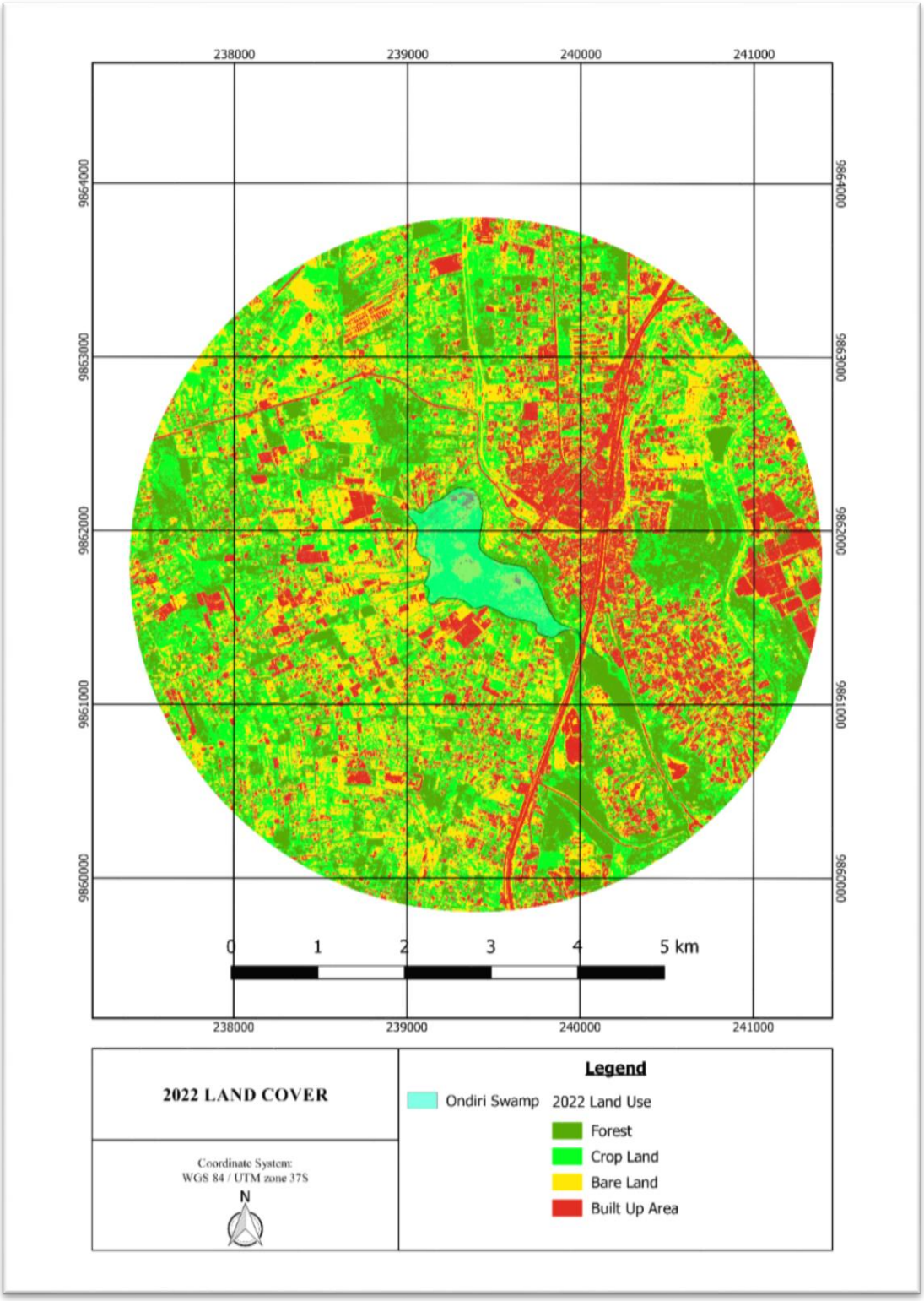
Figure 21:Land Cover Distribution in 2022



Source: Author,2022

The land cover classification for the year 2022 is displayed in Figure 22.

Figure 22: Land Cover in 2022



Source: Author,2022

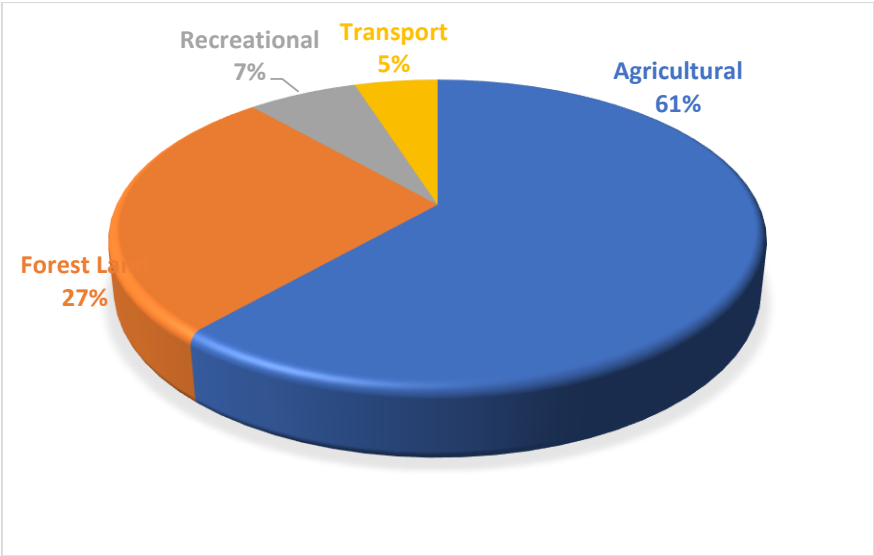
The analysis of the net changes in LULC within the buffer area over the period 2002-2022 shows that Forest Land recorded an increase of 5% and Bare Land also increased by 16%. Crop Land decreased by 36% whereas the Built Area increased by 15%.

An analysis of the land uses around the boundary of Ondiri Swamp which is approximately 3.6km shows that agricultural activities extend up to approximately 2.2km followed by some parts of tree cover which extend to approximately 900m. The portion with tree cover has tried to factor in environmental considerations that provide a buffer within the riparian zone of the swamp. A small section of an open space that is used as a recreational space also covers approximately 236m whereas the bypass cuts across a small section of the outlet of the swamp.

Table 1: Coverage of Land Uses Adjoining Ondiri Swamp

Land Uses	Coverage in Meters and Percentage	
Agricultural	2224.7	61%
Forest Land	976.6	27%
Recreational	236.3	7%
Transport	178.6	5%
	3616.2	100%

Figure 23: Percentages of Land Uses Adjoining Ondiri Swamp



Source: Field Study,2022

5.5 Conclusion

The increase in forestland is an indication of increased agro-forestry activities. The LULC trend analysis indicates conversion between Bare Land and Crop Land. This is as a result of differences in seasons (seasonality) when the satellite images were acquired in 2002 and 2022 as well as changing farm practices. Built-up areas have shown an increasing trend which is as a result of the increase in residential areas, commercial activities, education centres, and industries that have led to increased growth of buildings for settlement. Also, transportation networks have increased including the Southern Bypass.

CHAPTER SIX: FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

6.0 Introduction

This chapter presents the results, interpretation and discussion of the central findings, conclusions, and recommendations of this study. It also highlights the study's contribution to knowledge and the areas for further research.

6.1 Summary of Findings

The main findings of the study are the findings on the rural land use activities in the rural community that affect Ondiri Swamp, the urban land use activities in Kikuyu Town that affect Ondiri Swamp and the findings on the factors contributing to rural and urban land use negative effects on Ondiri Swamp.

6.1.1 Findings on Rural Land Use Activities in the Rural Community Affecting Ondiri Swamp

From the Land Use and Land Cover analysis, agricultural land use was the most dominant land use at the edges of Ondiri Swamp and generally within the study area. Intensive agricultural activities are carried out especially by the riparian landowners. The riparian landowners have access to the wetland and most of them harvest water for farming. In addition, several water pumps have been installed and pipes channelled to the farms for irrigation of crops using overhead irrigation. According to observations done in the course of this study, there were 44 temporary and permanent pumps drawing water from Ondiri Swamp. Greenhouses have also been installed for the agricultural activities to take place as shown in Plate 4.

Plate 4:Green Houses and Farmlands Creeping to the Edges of the Swamp

Source: Field,2022

Besides this study indicating the increase in forestland, deforestation has also been experienced especially at the periphery of Ondiri Swamp. According to the residents and professionals, massive cutting down of trees and natural vegetation within the wetland ecosystem over the years has been rampant. This has been practised to pave the way for developments that include the southern bypass, housing developments and agricultural activities. The absence of these trees increases the rate of soil eroding into Ondiri Swamp.

Plate 5 displays the indication of fallen trees near Ondiri Swamp.

Plate 5:Tree Stumps of Felled Trees within the Study Area

Source: Field 2022

With the study having noted the increase of forestland, the trees are majorly exotic trees, especially eucalyptus. The exotic trees have negative impacts of fast-growing characteristics because of high-water intake and high rates of transpiration. The exotic trees in return cause reduced water volume of wetland and inhibit the survival of underground undergrowth vegetation leading to soil erosion.

Despite the intensive agricultural activities within the rural community, the study has revealed increased development trends. Most farmers during the interviews conducted in this study expressed that farming is progressively becoming tough as the returns are low due to the high costs of agricultural inputs. This has led them to result in other land uses as the demand for land and housing has been the key force driving Kikuyu Town and its environments to accommodate the growing population. This has resulted in increased land subdivisions and the transformation of agricultural land into urban land use especially residential land use. Consequently, this has led to uncontrolled development, inadequate water supply and lack of sewer and wastewater treatment plants as most developments in the rural side still consider using septic tanks.

6.1.2 Findings on Urban Land Use Activities in Kikuyu Town Affecting Ondiri Swamp

From the land use land cover analysis, the increase in the built-up area indicates rapid urbanization. Kikuyu Town as an urban center has attracted a high population growth. The key drivers of the growth are because of the establishment of the town as a hub of commercial, industrial, institutional and administrative activities. Increased demand for residential property has also attracted people to the town due to its proximity to Nairobi City and is well served with good linkages e.g., the Southern, Northern Bypass, Nairobi-Nakuru Highway and other linkages including the Dagoretti - Mutarakwa Bypass, the newly tarmacked Ondiri Road and the well-graded access roads. Increased population also translates into increased urban development as shown in Plate 6.

Plate 6:Increased Population and Developments on Land Adjoining Ondiri Swamp

Source: (Field, 2022)

From the statistics collected in the field, most developments within Kikuyu have set up septic tanks to manage their liquid waste. The newly installed sewer infrastructure has

not yet been put into use. This means that the seepage of the liquid waste ends up in the Ondiri Swamp.

In recent years, the Ondiri Swamp has gained popularity and the population of people visiting the swamp for events, tours and picnics has increased as shown by the pitched tents in Plate 7. Most of them lack places to throw and end up littering and degrading the environment.

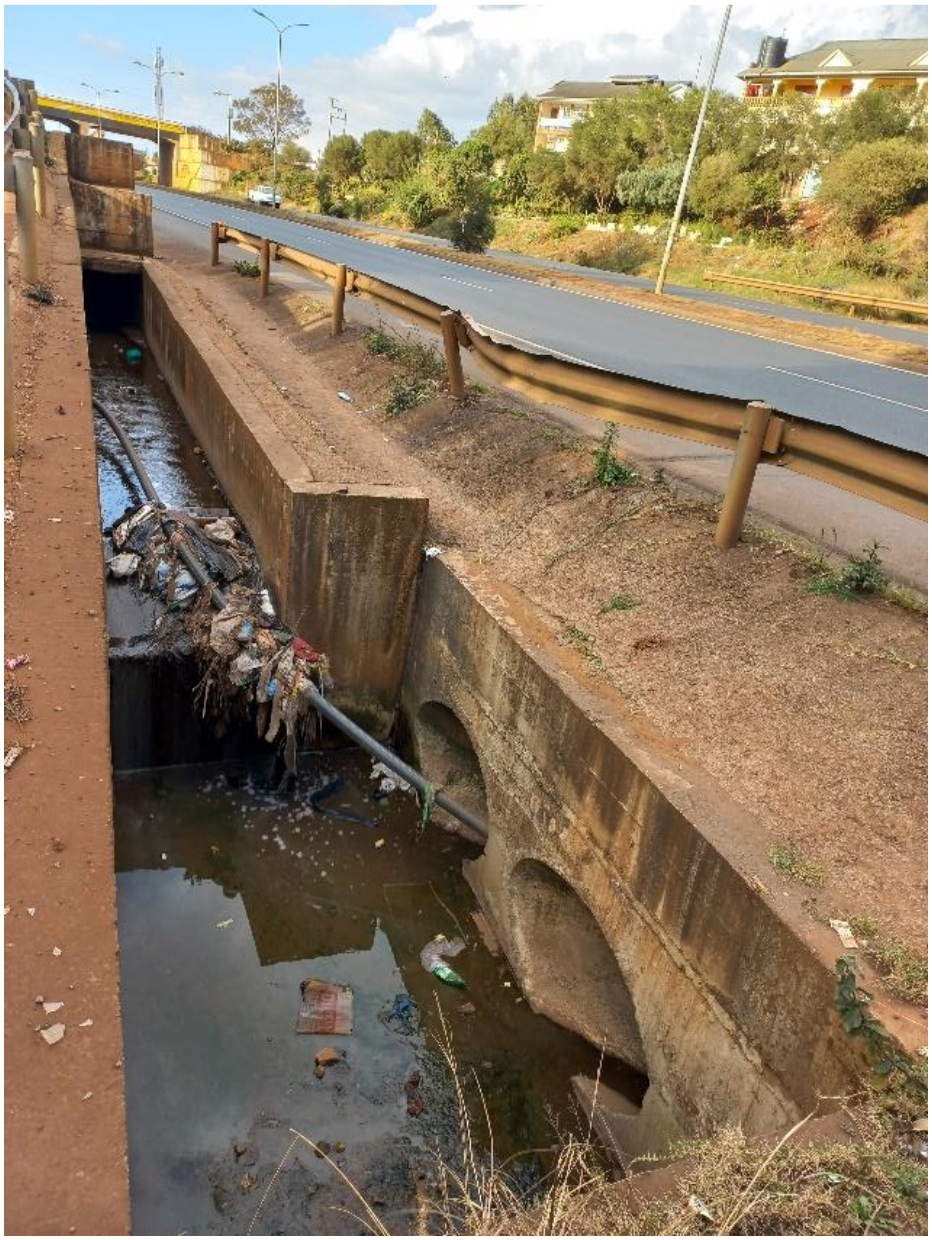
Plate 7: Events Taking Place At The Periphery Of Ondiri Swamp

Source: Field,2022

The growth, development, and population of the natural landscape within the Ondiri Swamp ecosystem have increasingly made sections of the area a concrete jungle. This is because of building structures with impervious material. As a result, there is an increased and accelerated surface run off water away from the recharge zone especially during the rainy season and that has caused the reduction of water percolating into the ground. This means that the groundwater recharge rate has been continuously declining.

During the construction of the Southern Bypass, a section of the swamp was canalized. That means that there was a diversion of the natural course of the wetland outlet. Users and nearby residents have in the course of the use of the bypass discovered a suffering on the bypass as the road expresses weak characteristics (Opera News, 2022). Other effects experienced from the bypass include the storm drains along the drainages by the side of the road that leads urban effluents and surface water into the wetland ecosystem as seen on Plate 8.

Plate 8:Storm Drainage Along the Southern Bypass Near The Wetland.



Source: Field, 2022

6.1.3 Findings on the Factors Contributing to Rural and Urban Land Use Activities in 6.1.1 and 6.1.2

The study has ranked the following factors as the contributing factors towards the rural and urban land use activities that affect the ecological functions and properties of Ondiri Swamp.

6.1.3.1 Overexploitation of the Wetland Resource

The unsustainable use of natural resources and overexploitation occurs when reaping the benefits of the wetland and exceeds to negatively impact the resource. Many people within the wetland ecosystem and those benefiting downstream derive maximum gains from the wetland yet few of them are involved in its conservation and management. The community is passive towards the conservation of the wetland. Increasingly the damage to the ecosystem functions and degradation happens with little or no attention from the community.

From the study, 90% of the respondents were aware that they directly or indirectly get water from Ondiri Swamp. Those who directly benefit are those that pump water directly from Ondiri Swamp with the main aim of farming whereas those who indirectly benefit is aware that the water they get is from Kikuyu Water Company which sources water from Ondiri Swamp.

However, few of the respondents take part in tree planting, effective solid and liquid waste management, and other efforts to ensure that the wetland is conserved.

6.1.3.2 Uncoordinated Stakeholder Efforts and Overlapping Institutional Mandates

Uncoordinated stakeholder efforts both from the state and non-state organizations have led to a lack of clear and common vision to guide and protect the wetland. Overlapping mandates on how stakeholders should report and function on matters of the wetland have created a complex landscape in the efforts to conserve the wetland. One of the respondents cited the duplication of roles between institutions, national and county

governments as one of the hindrances to the conservation and management of Ondiri Swamp. For instance, water abstraction is licensed by both NEMA and the WRA.

6.1.3.3 Inadequate Linkage Between Research, Planning and Policy Development

A lot of research work on wetlands both locally and internationally has not been borrowed to aid in the planning and development of policies to promote the wise use of the wetland in the study area. Harmful land use activities, especially on land adjoining the wetlands, have continuously been allowed on lands adjoining the wetland. The riparian width and the activities suitable within the riparian have not been clearly defined.

6.1.3.4 Weak Law Enforcement

As a result of weak institutional capacity and poor funding, enforcement is not carried out to apprehend illegal activities around Ondiri Swamp. One of the instances includes water abstractors who don't pay water charges. The illegal abstractors contravene the Water Act,2016 Section 36. Boreholes sunk without permits also contravene the Water Act,2016. Most farmers with greenhouses in the study area operate without Environmental Impact Assessment (EIA) approvals. The farmers using greenhouses without the EIA approvals contravenes EMCA,2015.

Finally, the land users conducting activities, especially agricultural within the periphery of riparian zones contravenes the Water Quality Regulations,2006 section 6 (c).

6.2 Summary of Conclusions

The main conclusions of the study are the conclusions on the rural land use activities in the rural community that affect Ondiri Swamp, the urban land use activities in Kikuyu Town that affect Ondiri Swamp and the conclusions on the factors contributing to rural and urban land use negative effects on Ondiri Swamp. These negative effects from both land uses have an impact on the quality and quantity of water at Ondiri Swamp.

The quality of water in Ondiri Swamp has been severely affected by pollution from both the urban and rural land uses. According to the environmentalists interviewed

during the study, the effects of pollution on the wetland include bacteria contamination, bad odour from the wetland, presence of heavy metals with significant concentration e.g., zinc, copper, lead and chromium. According to the water quality report developed by NEMA during this study, the result indicated the presence of impurities. Coliforms of 30 counts per 100 ml were traced and interpreted to have exceeded the limit. According to the World Health Organization, a zero count of coliforms per 100 ml of water is considered safe for drinking.

The test also revealed highly coloured water on some parts of the wetland and that has weighty effects on aquatic plants and algae growth. Light is essential for aquatic plant growth, and coloured water can reduce light penetration. As a result, a highly coloured body of water cannot support aquatic life, potentially causing long-term harm to the ecology. The cause of colour in the swamp was because of suspended particles which are as a result of when leaves, roots and other plant material slowly broken down into tiny particles that are essentially dissolved in the water.

The study concludes that there was high water abstraction from the wetland. Farmers, institutions including Alliance High School, Kiambu County and Kikuyu Water Company which has 10,200 customers, among others draw water from the swamp. According to WRA, there is uncontrolled and unmetered water abstraction from water pumps especially those without permits. Most respondents also noted the declining quantities and flow of water at the outlet of Ondiri Swamp as compared to previous years.

Plate 9 shows waters of low quantities flowing out of the Ondiri Swamp.

Plate 9: Water Flowing Out of Ondiri Swamp

Source: Field, 2022

6.2.1 Conclusions on Rural Land Use Activities in the Rural Community Affecting Ondiri Swamp

The implications of intensive agricultural activities around the wetland include the encroachment of cropland into the wetland. Moreover, the farmers have continuously released agrochemicals which include fungicides and pesticides into the wetland to increase soil fertility, control weeds as well as to eliminate pests. The chemicals are washed into the wetland during the rainy season. Also, loose soil from the farmlands is eroded during irrigation and deposited in the wetland because of reduced forest and vegetation cover near the wetland. Besides the exotic trees causing reduced water

volume of the wetland due to their high-water intake and high rates of transpiration they also inhibit the survival of underground undergrowth vegetation leading to soil erosion.

According to the professionals, the soil erosion results to sedimentation, clogging of underground recharge inlets, muddy water from the wetland especially during rainy seasons, increased land for parcels adjacent to the wetland used especially for agricultural activities as well as hardened shores of the wetland that have hardened the 'quacking bog'. The soil erosion and pollution by farm chemicals negatively affects the quality of water in the swamp.

Massive and unmetered water abstraction for agricultural purposes and domestic uses as well as the effect of exotic trees reduces the quantities of the water in the wetland.

The study also noted increased transformation of agricultural land into urban land use especially residential land use. The transformation negatively affects the natural landscape of the area.

6.2.2 Conclusions on Urban Land Use Activities in Kikuyu Town Affecting Ondiri Swamp

The growth, development, and population of the natural landscape within the Ondiri Swamp ecosystem have increasingly made sections of the area a concrete jungle. This means that the groundwater recharge rate has been continuously declining. The reduction of the groundwater recharge rate means less water quantities for Ondiri Swamp.

The quality of water in Ondiri Swamp has also been severely affected by pollution from the urban effluents. Water pollution happens mainly through increased sediment transport, people defecating along the shores of the wetland, percolation of waste from septic tanks near the wetland, farm chemicals especially fertilizers and pesticides from urban agriculture and dumping of waste by people using the wetland as a recreational site. Also, pedestrians and passengers using the linkages neighbouring the wetland and improper waste disposal by the Landowners adjoining the wetland contribute heavily to pollution.

Figure 10 shows a dumping site in an undesignated area near Ondiri Swamp.

Plate 10: Dumping Near the Wetland

Source: Field,2022

6.2.3 Conclusion on the Factors Contributing to Rural and Urban Land Use Activities

The study concludes that the community, land users and landowners adjoining the wetland are passive towards the conservation of the wetland. Uncoordinated stakeholder efforts and overlapping mandates from the state and non-state organizations have also led to a lack of clear and common vision to guide and protect Ondiri Swamp. The study also concludes that research has not informed planning and policies channelled towards the utilization of water, land and vegetation resources at the Ondiri Swamp, which has contributed to its continued ecological degradation. Finally, there is weak institutional capacity, poor funding and enforcement is not carried out to apprehend those negatively affecting Ondiri Swamp..

6.3 Recommendations

The study has recommended several land use planning interventions and strategies to address the rural and urban land use activities affecting the wetlands' ecological function. In addition, the study also highlights and recommends strategies that can effectively be used on the factors contributing to the negative rural and urban land use activities. The general aspiration of these recommendations is to improve the water access, quality, quantity at the Ondiri Swamp by ensuring sustainable conservation, protection and management practices are carried out by the stakeholders within the Ondiri Swamp ecosystem.

6.3.1 Recommendations on Rural Land Use Activities in the Rural Community Affecting Ondiri Swamp

The key issues that emerged in the rural land use activities in the rural community were unregulated water abstractions, water pollution from chemicals used during farming, high siltation rates, the presence of exotic trees as well as increased development trends.

The study therefore recommends controlled and metered water abstractions. Controlled and metered water abstractions will ensure illegal water abstractions are stopped, abstracted water to be regulated and awareness created to promote compliance with the water abstraction regulations. This strategy will greatly improve the water access and quantities at Ondiri Swamp.

The study recommends sustainable land use practices including organic farming, terracing and tree planting to minimize the effects of pollution and high siltation rates. However, exotic trees should be eliminated. The farmers near the wetland should be encouraged to practice organic farming. Organic agriculture reduces the agrochemical needs which are the major polluters of the wetland. Organic agriculture also plays a significant role in reducing greenhouse emissions and global warming through its ability to sequester carbon in the soil. In addition, since the slope of land adjoining the wetland is steep, terracing and sustainable tree planting would be recommended. The terraces help improve the landscape as well as reduce the rate of soil eroded into the Ondiri Swamp.

Finally, increased development trends within the rural community should be minimized by controlling land use changes. Agricultural land use should be maintained by ensuring

that large and sustainable land sizes are maintained. The agricultural land use will be beneficial as it will promote the economic gains of the farmers as well as retain the natural landscape of the area.

6.3.2 Recommendations on the Urban Land Use Activities in Kikuyu Town Affecting Ondiri Swamp

The key issues that emerged in the Urban Land Use Activities in Kikuyu Town Affecting Ondiri Swamp were the increased urbanization trends, mismanagement of solid and liquid waste as well as the increased and accelerated surface runoff from Kikuyu Town.

The study recommends maximizing urban development designs to help infiltrate stormwater and help recharge underground water. Some designs should be fitted or should accommodate green infrastructure that includes green spaces and infrastructures with pervious surfaces that help water to percolate and add into the recharge zones. Green infrastructures for stormwater are natural and engineered systems that blend with the built environment to improve water quality, enhance the natural hydrologic process, maximize the use of storm water as a resource, and provide a wide range of ecological, community, and infrastructure services. Additionally, these green infrastructures slow down water flow to allow for maximum infiltration of water into aquifers.

The study recommends the collection and proper disposal of solid waste to manage solid waste. In addition, to control litter channelled through stormwater conduits, litter catchment nets, as shown in Plate 11, that help in the removal of urban effluents should be installed.

Plate 11: Net for Trapping Litter

Source: www.boredpanda.com

To control liquid waste from septic tanks, the users should ensure the waste is contained within the septic tanks. The goal should however be to connect the urban and rural land users to a sewer infrastructure.

6.3.3 Recommendations on the Factors Contributing to Rural and Urban Land Use Activities

The study recommends interventions and strategies that are meant to secure and regulate access to the wetland and the wetland resources from overexploitation, to promote stakeholder involvement and conservation, to provide linkages between research, planning and policy development as well as to ensure law enforcement.

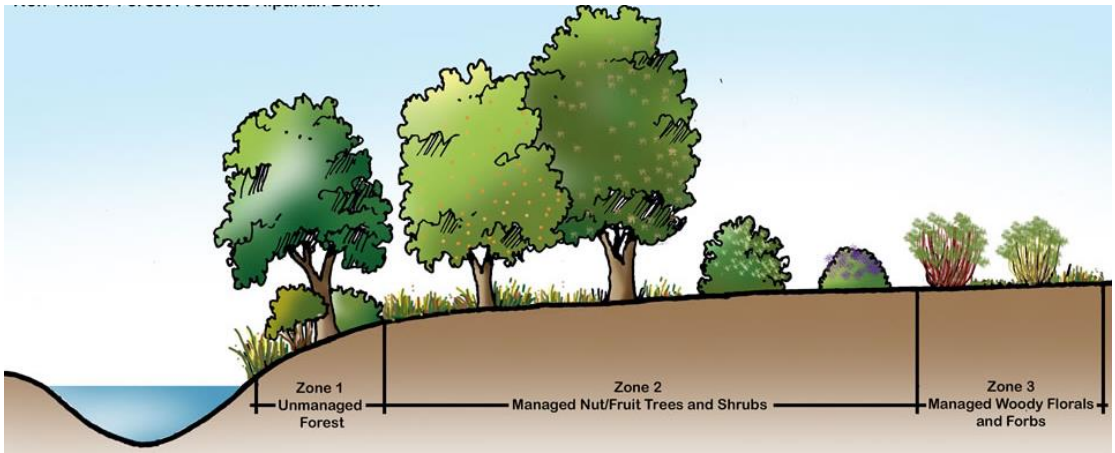
Securing and regulating access to wetland resources will control the overexploitation of the wetland and its resources. Since the Ondiri Swamp boundary is not well defined, a land survey process is essential to define the extent of the wetland. Enhancing the cartography of wetland areas is crucial in order to accomplish specific regional conservation objectives, as they rely on precise spatial information. Hiestermann et al. (2015) found that the existing techniques used to map wetlands by analyzing satellite

pictures often underestimate the actual extent of wetland areas. The importance of auxiliary data in improving the accuracy of wetland mapping has been acknowledged.

However, mapping and realigning the wetland boundary from existing survey plans of parcels neighbouring the wetland would be a sure way of defining the Ondiri Swamp boundary. A proper fence is also essential in securing and regulating access to the wetland.

To further maintain the ecological properties of the wetland, the definition and establishment of an adequate and highly vegetated riparian buffer zone with the three-zone concept that addresses surface water, subsurface water and underground water will be required to protect a belt of natural or adaptive vegetation. Plate 12 shows the three-buffer zone.

Plate 12: The Three-Zone Buffer Concept to Protect the Wetland



Source: USDA National Agroforestry Centre,2015

The zone should be 30m for both rural and urban land uses adjoining the wetland. The advantages of creating a buffer to protect the wetland include noise reduction, water temperature moderation, nutrient uptake, sediment removal, stormwater retention and wetland preservation, pollution reduction, protect biodiversity, reduced water energy flow soil erosion and sedimentation into the swamp as well as wetlands bank stabilization.

The strategies for managing the wetlands and the development of land use plans on lands adjacent to wetlands should be properly defined to promote the wise use of wetlands. This study recommends open spaces adjoining the wetland to be utilized for recreational activities. A track around the wetland can also be established for monitoring purposes and can also add up as a jogging track for recreational purposes.

In the stakeholder and institution involvement in the conservation of the wetland, the study recommends the establishment of a directorate of wetlands that will ensure a strong institutional and regulatory framework and provide a clear roadmap to improve compliance and enforcement of wetlands conservation and management in accordance with the Constitution, Vision 2030 and other key policy development instruments ensuring sustainable development of wetlands.

The community and the institutions involved should, however, be actively involved in their basic role of protection of the wetland. The rural community should be engaged and taught proper ways to practice agriculture as well as how they should dispose of their waste. Urban dwellers should also be involved in activities and practices that do not directly affect the wetland negatively. Also, water harvesting, and storage mechanisms should be encouraged to reduce the usage of water abstracted from the wetland and to reduce runoff water. The upstream river users should be tasked to protect the sources of water and the downstream water users should be tasked to conserve water.

The following institutions should strictly adhere to their roles to help in the conservation of the wetland. Kenya Forest Research Institute (KEFRI) should undertake research, provide technologies and information for the long-term management, conservation, and development of forests and other natural resources. The National Environmental Management Authority (NEMA), Water Resources Authority (WRA) and the County Government of Kiambu should spell out their roles in providing civic education on sustainable management of Ondiri Swamp, rehabilitating degraded aspects of the wetland ecosystem and ensuring law enforcement. The study also proposes the concept of partnership to bring together all the stakeholders together to achieve the common goal of conserving the wetland.

In addition, the study recommends that research should inform the planning and utilization of water, land, and vegetation resources at the Ondiri Swamp. Providing

linkages between research, planning and policy development helps in the planning and development of policies and projects that promote ecological management, tourism development, community partnership and natural resource management.

Finally, the study recommends that the environmental management enforcement agencies concerned should ensure compliance with environmental laws and policies. They should also be mandated to take civil or criminal enforcement action against violators of environmental laws. These agencies should also ensure and spearhead the enactment of laws, sound policies and enforcement which are important for guarding upstream and protecting downstream interests as well as development regulations near the wetland.

6.4 Contribution to Knowledge

By demonstrating that land use activities within rural communities and urban centers that are adjacent to wetlands have a direct impact on the biological functions of wetlands, this study contributes to the body of scientific knowledge that will be used for future reference. Moreover, it provides a comprehension of the specific aspects within the rural community as well as the urban centres that affect the wetlands. The study therefore is useful for context-specific decision making that will promote the wise use of wetlands.

6.5 Areas for Further Research

This study has demonstrated how rural and urban land use affects the ecological functions of wetlands. However, the intensity of the impacts on the wetland posed by the rural and urban land uses may vary. A study should therefore be done to determine the optimum riparian widths for the specific land uses, which includes the rural and urban land uses adjoining the wetland.

References

Ajibola B. O., M.O. Oduwaiye, Akangbe, & Komolafe. (2012). An Assessment of Knowledge of Farming-Related Hazards and Precautionary Practices of Farmers in Kwara State, Nigeria. Journal Of Research in Forestry, Wildlife and Environment. 7(2), 27-34. https://www.Researchgate.Net/Publication/324943747

Alberta Wetland Policy. (2020). Wetland Mitigation. http://www.wetlandpolicy.ca/wetland-mitigation

Amani, M., Salehi, B., Mahdavi, S., Granger, J., & Brisco, B. (2017). Wetland classification in Newfoundland and Labrador using multi-source SAR and optical data integration. GIScience & Remote Sensing, 54(6), 779–796. https://doi.org/10.1080/15481603.2017.1331510

Baez, A. V., Knamiller, G. W., & Smyth, J. C. (1987). The Environment and Science and Technology Education. Elsevier.

Bezabih, B., & Mosissa, T. (2017). Review on Distribution, Importance, Threats, and Consequences of Wetland Degradation in Ethiopia. International Journal of Water Resources and Environmental Engineering, 9(3), 64–71. https://doi.org/10.5897/Ijwree2016.0697

Briassoulis, H. (2001). Policy-Oriented Integrated Analysis of Land-Use Change: An Analysis of Data Needs. Environmental Management, 27(1), 1–11. https://doi.org/10.1007/S002670010129

Broome, S. W., Craft, C. B., & Burchell, M. R. (2019). Tidal Marsh Creation. Elsevier, 789–816. https://doi.org/10.1016/b978-0-444-63893-9.00022-8

Cox, J. W., & Ashley, R. (2000). Water quality of gully drainage from texture-contrast soils in the Adelaide hills in low rainfall years. Australian Journal of Soil Research, 38(5), 959–972. https://doi.org/10.1071/Sr99106

Davidson, N. C. (2018). Ramsar Convention on Wetlands: Scope and Implementation. In The Wetland Book I: Structure and Function, Management, and Methods (Pp. 451-458). Springer.

Finlayson, C., & Gardner, R. C. (2018, October 5). Global Wetland Outlook: State of the World's Wetlands and Their Services to People. https://ssrn.com/abstract=3261606

Gambrel, E. (2019). Wetland Plants & Wildlife. https://sciencing.com/wetland plants wildlife 8254793.html

Garbisch, E. (2019). Wetland Restoration: Changing Techniques, Changing Goals, Changing Climate. Wading Right In Discovering The Nature Of Wetlands, 191.

Gerbeaux, P., Finlayson, C., and Van Dam, A. (2018). Wetland Classification: Overview. In The Wetland Book I: Structure and Function, Management and Methods (pp. 1461-1468). Springer. https://doi.org/10.1007/978-90-481-9659-3_329

Global Wetland Outlook. (n.d.). Retrieved November 1, 2021, From https://www.Global-Wetland-Outlook.Ramsar.Org/.

Hardin, G. (1968). The Tragedy of The Commons. Science, 162(3859), 1243–1248. https://doi.org/10.1126/Science.162.3859.1243

Hiestermann, J., & Rivers-Moore, N. (2015). Predictive Modelling of Wetland Occurrence in Kwazulu-Natal, South Africa. South African Journal of Science, 111(7–8), 1–10. https://doi.org/10.17159/Sajs.2015/20140179

Jeng. (2016). 5 Ways to Protect Wetlands on Your Property, Applied Resource Management, Pc. https://armnc.com/5 ways to protect wetlands on your property/

Jowsey, E. (2007). A new basis for assessing the sustainability of natural resources.

Energy, 32(6), 906–911. https://ideas.repec.org/a/eee/energy/v32y2007i6p906-911.html

Kinyanjui, D. M. (2003). Palynology, and heavy metals in the sediments and water of the Ondiri Swamp, Kikuyu, Kenya: Past influences, present practices, future needs. http://repository.uonbi.ac.ke/Handle/11295/24276

Koning, C. O., & Ashworth, S. M. (2019). Wetland Restoration: Changing Techniques, Changing Goals, Changing Climate. In Wading Right (Pp. 191–218). University Of Chicago Press. https://doi/10.7208/9780226554495-010/html

Lumen Learning. (2020). Introduction to natural resource economics. Boundless Economics. https://courses.lumenlearning.com/boundless-economics/chapter/introduction-to-natural-resource-economics/

Mahlatini, P., Hove, A., Maguma, L. F., & Chemura, A. (2018). Using Direct Use Values For Economic Valuation Of Wetland Ecosystem Services: A Case Of Songore Wetland, Zimbabwe. Geojournal, 85(1), 41–51. Https://doi.org/10.1007/s10708-018-9947-3

Matthews, G. V. T. (1993). The Ramsar convention on wetlands: its history and development gland: Ramsar Convention Bureau. https://leap.unep.org/sites/default/files/2020-09/Matthews-history.pdf

Mccullough, G. B. (2018). Wetland Threats and Losses in Lake St. Clair. In Coastal Wetlands (Pp. 201-208). CRC Press.

Mccullough, G. B. (2018). Wetland Threats and Losses in Lake St. Clair. Coastal Wetlands, 201–208. https://doi.org/10.1201/9781351070720-13

Moore, H. H., Niering, W. A., Marsicano, L. J., & M. Dowdell. (1999). Vegetation Change in Created Emergent Wetlands (1988-1996) in Connecticut (USA). Wetlands Ecology and Management, 7(4), 177–191.

Moore, P. D. (2006). Biomes of the Earth; Wetlands. Chelse House Publishers.

Mucheye, T., Yitaferu, B., & Zenebe, A. (2018). Significance Of Wetlands for Sediment and Nutrient Reduction In Lake Tana Sub-Basin, Upper Blue Nile Basin, Ethiopia. Sustainable Water Resources Management, 4(3), 567–572. https://doi.org/10.1007/S40899-017-0140-5

Mucheye, T., Yitaferu, B., and Zenebe, A. (2018). Significance of Wetlands for Sediment and Nutrient Reduction in Lake Tana Sub-Basin, Upper Blue Nile Basin, Ethiopia. Sustainable Water Resources Management, 4(3), 567-572.

Mwathi, P. M. (2016). Effects Of Land Use and Land Cover Dynamics on Environmental Quality of Nairobi City and Its Environs. http://repository.uonbi.ac.ke/Handle/11295/97377

News, O. (2022). Kenyans In Panic as Bridge Just Before Kikuyu Town Along Southern Bypass Is Reported to Be Sinking. https://ke.opera.news/ke/en/society/A4a54f04452fef50046241f27d1ba5c6

Njogu, J. G., & Dietz, T. (2006). Land Use and Tenure: Entitlement Rights for Community-Based Wildlife and Forest Conservation In Taita Taveta, Kenya. https://opendocs.ids.ac.uk/opendocs/handle/20.500.12413/1053

Parikh, J. K., & Datye, H. S. (2003). Sustainable Management of Wetlands Biodiversity and Beyond. Sage Publications.

Pigou A. C. (1929). The Economics of Welfare (4th Ed.). http://files.libertyfund.org/files/1410/0316_Bk.Pdf

Rafiq, R., Alam, M. S., Rahman, M. M., & Islam, I. (2014). Conserving Wetlands: Valuation Of Indirect Use Benefits of A Wetland Of Dhaka. International Journal of Environmental Science and Development, 5(1), 64–69. Https://Doi.Org/10.7763/Ijesd.2014.V5.452

Rebelo, L. M., Mccartney, M. P., & Finlayson, C. M. (2010). Wetlands Of Sub-Saharan Africa: Distribution and Contribution Of Agriculture To Livelihoods. Wetlands Ecology and Management, 18(5), 557–572. Https://Doi.Org/10.1007/S11273-009-9142-X

Reid, Walter & Mooney, Harold & Cropper, A & Capistrano, D & Carpenter, Stephen & Chopra, & Kartik. (2005). Millennium Ecosystem Assessment. Ecosystems And Human Well-Being: Synthesis. https://www.researchgate.net/publication/297563785 millennium ecosystem assessment ecosystems and human well-being synthesis

Ricardo, D. (1817). Principle Of Political Economy and Taxation. https://socialsciences.mcmaster.ca/econ/ugcm/3ll3/ricardo/principles.pdf

Schwartz, S. H. (1992). Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests In 20 Countries. Advances In Experimental Social Psychology, 25(C), 1–65. Https://Doi.Org/10.1016/S0065-2601(08)60281-6

Stern, P., Dietz, T., Abel, T., Guagnano, G., & Kalof, L. (1999). A Value-Belief-Norm Theory of Support for Social Movements: The Case Of Environmentalism. Human Ecology Review, 6(2), 1–12. https://www.jstor.org/stable/24707060?seq=1#metadata info tab contents

The Constitution of Kenya. (2010). https://www.kenyalaw.org

The Royal Society for The Protection of Birds. (2021). https://www.rspb.org.uk/reserves-and-events/reserves-a-z/ouse-fen/

Trišić, I. (2019). The Significance of Wetlands for the Sustainable Tourism of the Autonomous Province of Vojvodina. Turističko Poslovanje, (23), 29-41.

Trišić, I. (2019). The Significance of Wetlands For The Sustainable Tourism Of The Autonomous Province Of Vojvodina. Turističko Poslovanje, 23, 29–41. https://doi.org/10.5937/turpos0-22024

Turner, R. K., Bergh, J. C. J. M. Van Den, Barendregt, A., & Maltby, E. (1998). Ecological-Economic Analysis of Wetlands. Tinbergen Institute Discussion Papers. https://www.researchgate.net/publication/4781403_ecological-economic analysis of wetlands

Yale Climate Connections. (2019). https://yaleclimateconnections.org/2019/05/salt-marshes-help-protect-shorelines/

Zedler, J. B., and Kercher, S. (2005). Wetland Resources: Status, Trends, Ecosystem Services, and Restorability. Annual. Revision Environmental Resource, 30, 39-74.

APPENDICES

Appendix 1: Research Work Plan

	Timeline(weeks)									
	4	2	8	4	2	2	2	2	1	1
TASK										
Desktop review										
Problem identification										
Proposal Writing										
Literature review										
Consultation										
Data collection										
Data analysis										
Presentation										
Submission of report										
Conclusion										

Appendix 2: Research Budget Estimates

Budget Item	**Quantity**	**Cost (Ksh.)**	
		Cost per unit	**Total Cost**
Mileage claims for reconnaissance study and field work	10 trips	600kshs/per trip	6,000
Printing field instruments	100 Copies (10 pages per copy)	5kshs/page	5,000
Data acquisition (survey maps)	10 copies	600kshs/map	6,000
Field level facilitations (Community Guide)	2 people (5 Days)	2000 per day	20,000
Printing and binding			10,000
Grand Total (Ksh.)			47,000

Appendix 3: Household Questionnaire

HOUSEHOLD QUESTIONNAIRE

Questionnaire No.	

Information for Respondents:

I am a second-year student at the University of Nairobi taking a degree course in Master of Arts in Planning i.e. M.A. (Planning) in the Department of Urban and Regional Planning. I am collecting data as a part of my field work in conducting a study titled: **"Appraisal of Urban and Rural Land Uses for Sustainability in Wetland Conservation: A Case of Ondiri Swamp, Kikuyu Sub-County"**

Please note that the information that you give will be treated in confidence and strictly used to write the research report for academic purposes only.

Your assistance will be highly appreciated. THANKS.

Name of Interviewer:	
Date of Interview:	
Area:	

SECTION A: PROFILE OF RESPONDENT

1. Age…….
2. Gender …….
   a) Male
   b) Female
3. Are you the household head? …….
   a) Yes
   b) No
4. If no in 6 above, what is your relationship with the Household head?

……..

a) Spouse
b) Daughter in Law
c) Son
d) Grandchild
e) Daughter
f) Son in Law
g) Other (Specify)

5. Level of education?

…….

a) None
b) Primary
c) Secondary
d) Tertiary

6. Source of income

Source	Specify	Monthly Income
Business		
Agriculture		
Employment		
Other		

7. Household monthly expenditure

a) Below 5,000
b) Between 5,000- 10,000
c) Between 10,000- 15,000
d) Between Over 15,000

8. Were you born in this area? ……

a) Yes
b) No

9. If No in 3, when did you migrate to this area?

.....

10. Name reason for migrating to this area?

….....

a) To Work
b) Purchased land
c) Allocated land
d) Inherited land
e) Got Married and settled
f) To do business
g) To engage in farming
h) Any other

SECTION B: LAND USE AND LAND SYSTEMS

11. Do you own the land you reside on?.....

a) Yes
b) No

12. If Yes, how did you acquire the land? …….....

a) Inheritance
b) Lease
c) Government Allocation
d) Purchase
e) Others(specify)

13. What land ownership documents do you have?

a) Leasehold Title
b) Freehold Title
c) Share Certificate
d) Rental
e) Allotment letter

14. Type of land

a) Public
b) Private
c) Community

15. Size of land in acres…….

16. Current land use type…….

a) Agricultural
b) Residential
c) Commercial
d) Recreational
e) Industrial

17. What was the use of the parcel before you occupied it?

……

18. Do you have any plans to change the current use? …….

a) Yes
b) No

19. If Yes, which is the preferred land use you wish to change to…….

……

SECTION C: ENVIRONMENT AND NATURAL RESOURCES

20. What (kind of) problems does the wetland ecosystem face? Tick category

Problem	**Source**	**Rank by Severity**				
		1st Most Frequent	**2nd Frequent**	**3rd Least Frequent**	**N/A**	**Effects**
Deforestation						
Wetland Pollution						
Air Pollution						
Noise pollution						

Solid waste mismanagement						
Encroachment into the wetland						
Soil Erosion						
Land slides						
Others						

21. How often do you experience the effects of the above environmental challenges on the wetland ecosystem? Tick category

Effects	**Most Frequent**	**Frequent**	**Least Frequent**	**N/A**
Landslides and soil erosion				
Poor aesthetics				
Water and airborne diseases				
Poor water quality				
Reduced quantity of water				
Wetland resource conflict				
Others(specify)				

22. What intervention measures as an individual/household have you put in place to mitigate the above environmental challenges?

……

SECTION D: PHYSICAL AND SOCIAL INFRASTRACTURE PROVISION

23. Source of water…….

a) Kikuyu Water

b) Ondiri Swamp

c) Borehole

24. How adequate are the current sources of water……?

a) Very adequate

b) Adequate

c) Somewhat Adequate

d) Inadequate

25. Challenges faced in accessing water…….

…….

26. How do you dispose solid waste? ……

……..

27. Which institutions deal with waste management in the area?.....

……

28. How do you dispose human waste?.....

…….

SECTION E: PERCEPTIONS AND UTILIZATION OF ONDIRI SWAMP

29. What opportunities/benefits does the wetland present to you?

……

……..

30. How do you protect the wetland?

……

……..

31. In your opinion, which activities and developments are harmful to the wetland?

……

……

32. In your opinion, which are the best catchment activities and developments suitable for the wetland?

……

……

33. In your opinion, who should be involved in the protection of the wetland?

……
……

34. In your assessment using a scale of 1 to 5 indicate your opinion of the impacts associated with each of the following rural-urban land uses on the wetland and state their effects.

No.	**Rural/Urban Land Use Types**	**Impact On Wetland** a) No Effect b) Minimal Effect c) Moderate Effect d) Significant Effect **e)** Major Effect	**Effect**
1.	Agriculture		
2.	Residential		
3.	Commercial		
4.	Industrial		
5.	Recreational spaces		
6.	Physical infrastructure e.g. Southern Bypass		

End of Survey

Appendix 4: Key Informant Guide

Information for Respondents:

I am a second-year student at the University of Nairobi taking a degree course in Master of Arts in Planning i.e. M.A. (Planning) in the Department of Urban and Regional Planning. I am collecting data as a part of my field work in conducting a study titled: **"Appraisal of Urban and Rural Land Uses for Sustainability in Wetland Conservation: A Case of Ondiri Swamp, Kikuyu Sub-County."**

Please note that the information that you give will be treated in confidence and strictly used to write the research report for academic purposes only.

Your assistance will be highly appreciated. THANKS.

Name of Interviewer:	
Date of Interview:	
Organization:	
Department:	

1. What is the role of your organization/ministry/department in use and management of Ondiri Swamp?
   ……..
   .....
   .....
   .....

2. What role do you play as an officer in this organization/ministry/department in the determination, use and management of Ondiri Swamp?.....

.....
.....
.....
.....

3. In your opinion, what rural catchment activities have affected the existence and functioning of Ondiri Swamp?

.....

.....

.....

4. In your opinion, what urban catchment activities have affected the existence and functioning of Ondiri Swamp?

.....

.....

.....

.....

5. In your assessment using a scale of 1 to 5 indicate your opinion of the impacts associated with each of the following rural-urban land uses on the wetland

No	**Rural/Urban Land Use Types**	**Impacts On Wetlands** a) No Effect b) Minimal Effect c) Moderate Effect d) Significant Effect e) Major Effect	**Effect**
1.	Agriculture		
2.	Recreational spaces		
3.	Physical Infrastructures e.g., (avoid e.g.) Southern Bypass		
4.	Residential		
5.	Institutions		
6.	Commercial		
7.	Industrial		
8.	Other land uses		

6. Has this organization/ministry/department attempted to stop negative effects on Ondiri wetland?
   a) Yes
   b) No
7. If Yes in 6 above, how and what challenges did your organization / ministry / department face?

   .....

   .....

   .....

8. Does your organization have technical human capacity to oversee effective conservation of wetlands?

   …….

……

……

9. Which organizations do you consult with?

.....……

……

10. Which organizations do you collaborate with?

.....……

……

11. What informs the land uses adjacent to wetlands?

    .....

    .....

    .....

12. What policies are used by your organization for managing wetlands?.....

.....

.....

.....

13. In your opinion, how would conservation of Ondiri wetland be achieved?

    .....

    .....

    .....

14. What possible management measures or strategies would ensure the wise use of Ondiri wetland?

.....

.....

.....

End of Survey

Appendix 5: Observation Checklist

A. Environmental Sector

1. State of Ondiri Swamp

Take photos

2. Activities being undertaken on the land bordering to the wetland and the wetland ecosystem

Take photos

3. Land cover of parcels adjoining the wetland
   a) Trees
   b) Crops
   c) Bare Land
   d) Built Up Area

Take a photo

4. Land use types of lands adjacent to the wetland

Take a photo

Take a photo

5. Accessibility of land next to wetland
   a) Open to public use
   b) fenced off
   c) built on up to edge of wetland
   d) Private use
   e) other Specify……

Take a photo

6. Quality of water results from water tests done within the wetland(NEMA)

……..

7. Flow(Q) of water from the wetland over the years(WRA)

.....

B. Physical Infrastructure

Name of sub sector	**Condition 1. Very good 2. Good 3. Average 4. Bad 5. Very bad**	**Take a photo**
Water Pumps		
Ondiri Swamp outlet		
Solid waste collection sites		
Storm water drainages		

End of Observation List

Appendix 6: National Environment Management Authority (NEMA) Report on Water Quality in Ondiri Swamp

NATIONAL ENVIRONMENT MANAGEMENT AUTHORITY

WATER QUALITY MONITORING REPORT

MEASUREMENT OF FRIENDS OF ONDIRI SWAMP WATER DURING WORD WETLAND DAY CELEBRATION AT KIKUYU, KIAMBU COUNTY

Location : Friends of Ondiri Swamp, Muguga, Kikuyu, Kiambu County

GPS : 1°25'00.464"S 36°66'48.771"E

Description of Sample : Swamp water (collected next to water pump)

Sample No. : LAB/0001/22

Weather : Clear sky and Sunny

Date and Time Sampled : 2nd February, 2022 at 10.45 am

Sampled Collection : NEMA

Measurements compared to quality standards for sources of domestic water standards as outlined in the Water Quality Regulations 2006.

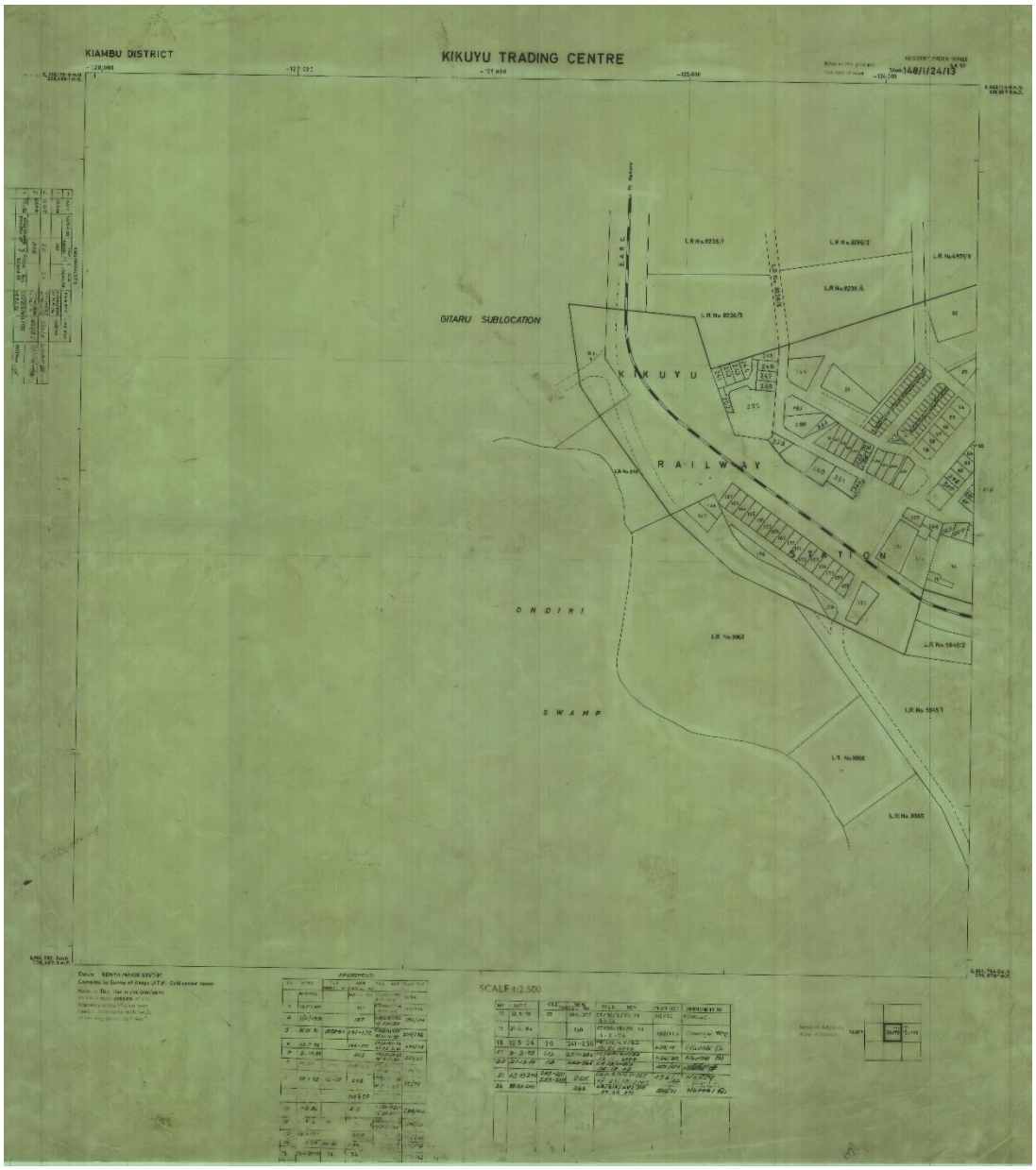
Lab Sample Report Form			
Parameter	RESULTS		Remarks
	Test Value	*Guide Value (mar allowable)*	
pH	6.5	6.5 – 8.5	Ok
Suspended solids	13 mg/l	30 (mg/L)	Ok
Total Dissolved Solids	117 mg/l	1200 (mg/L)	Ok
Total Coliforms	TMTC	30 (Counts/100ml)	Exceeds Limit
E. Coli	-	Nil/100 ml	
Temperature	26°C	±3 based on ambient temperature	Ok

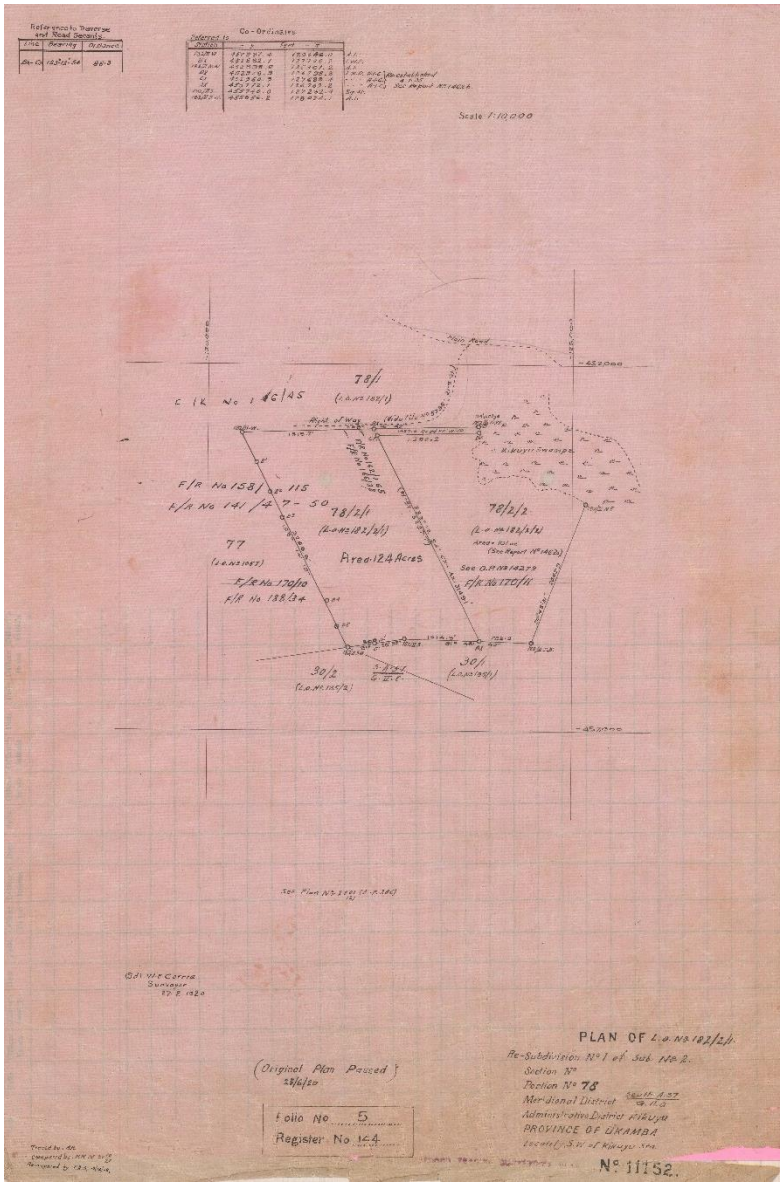
Cadmium	<0.003 mg/l	0.01 (mg/L)	Ok
Lead	<0.003 mg/l	0.05 (mg/L)	Ok
Chemical Oxygen Demand	20 mg/l	50 (mg/l)	Ok
Electrical Conductivity	250 µS/cm	500 µS/cm	Ok
Copper	0.025 mg/l	0.05 (mg/L)	Ok
Zinc	0.11 mg/l	1.5 (mg/L)	Ok
Color	124 H.U	15 Hazen Units	Exceeds the limit

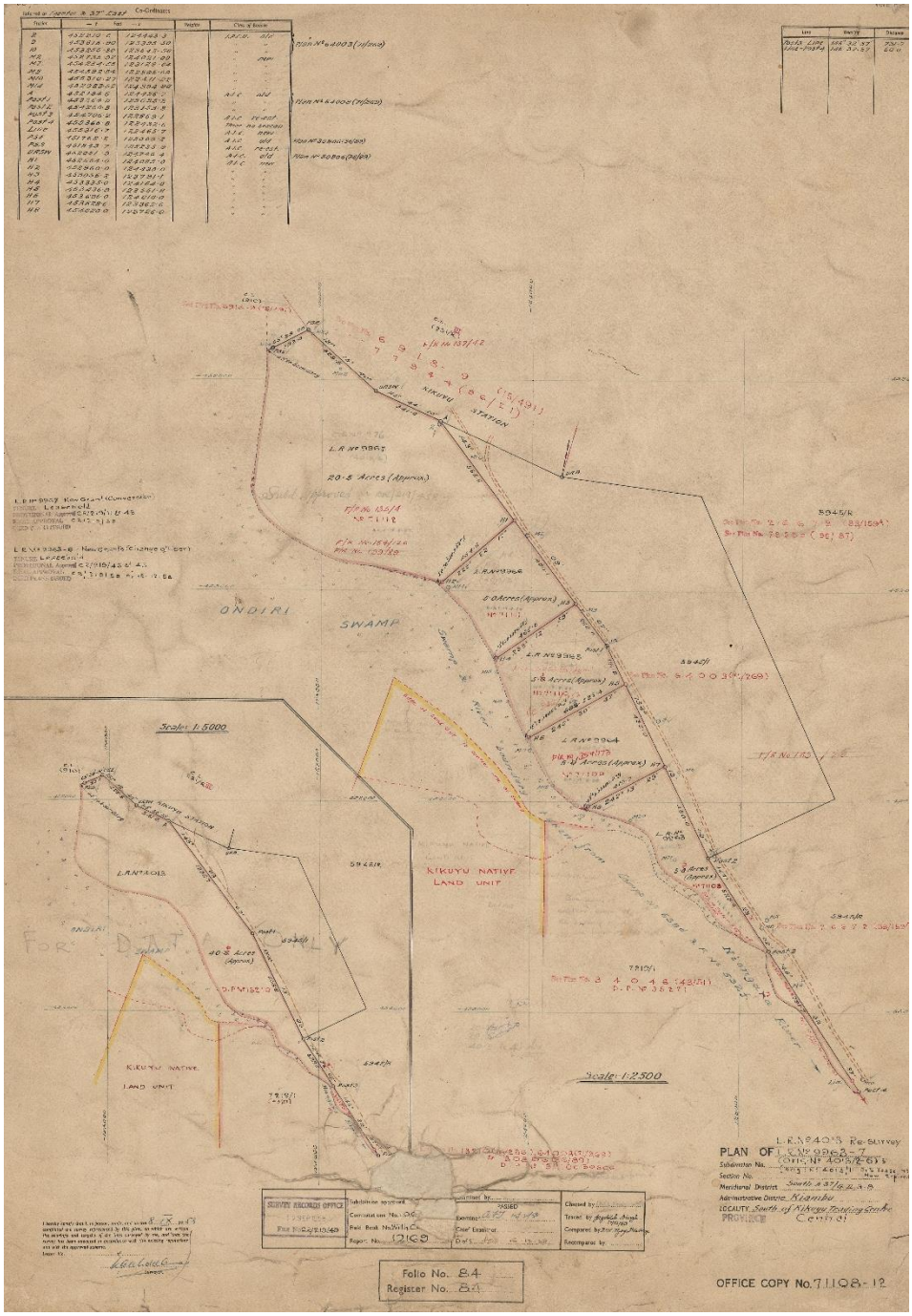
Comments:

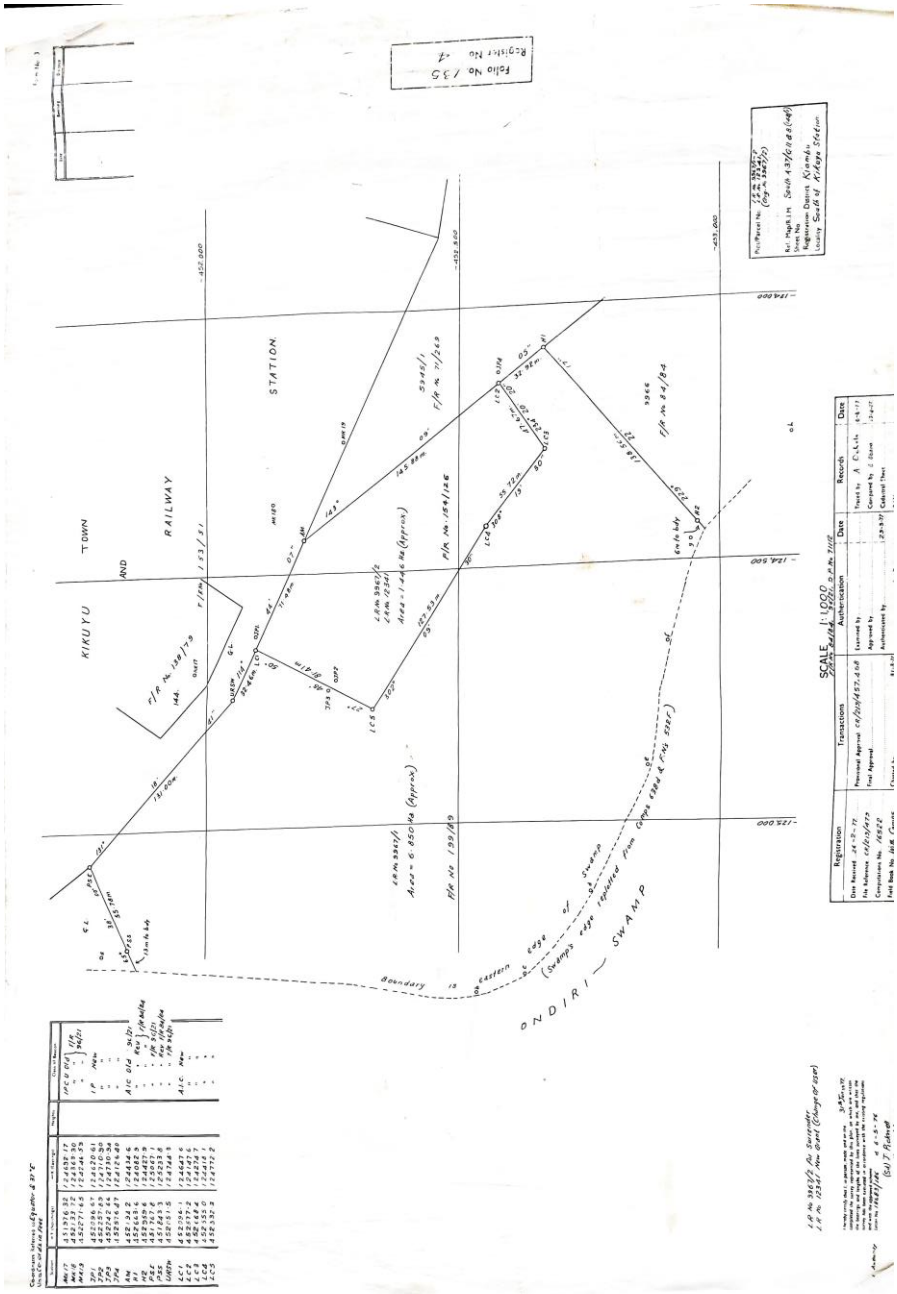
Highly colored water has significant effects on aquatic plants and algae growth. Light is very critical for the growth of aquatic plants and colored water can limit the penetration of light. Thus a highly colored body of water could not sustain aquatic life which could lead to the long term impairment of the ecosystem. The cause of colour in the swamp was because of suspended particles which are as a result of when leaves, roots and other plant material is slowly broken down into tiny particles that are essentially dissolved in the water.

Appendix 7: Survey Plans used to define the Boundary of Ondiri Swamp




Co-ordinates
Scale 1:10,000
78/1
(L.o.No.102/1)
F/R No 158/ 115
F/A No 141 /4 7-50
78/2/1
(L.o.No.102/2/1)
78/2/2
(L.o.No.102/2/2)
77
(L.o.No.102/1)
Area 124 Acres
30/2
(L.o.No.102/2)
30/1
(L.o.No.102/1)
PLAN OF L.o. No. 102/2/1.
Re-Subdivision No 1 of Sub. No 2.
Section No 78
Meridional District
Administrative District Kikuyu
PROVINCE OF UKAMBA
Located S.W. of Kikuyu Stn.
(Original Plan Passed)
28/6/20
Folio No 5
Register No 14
No. 11152.


KIKUYU STATION
ONDIRI SWAMP
Scale 1:5000
KIKUYU NATIVE LAND UNIT
Scale 1:2500
PLAN OF
OFFICE COPY No.71108-12
Folio No. 84
Register No. 84


Folio No 135
Register No 4
KIKUYU TOWN
RAILWAY STATION
ONDIRI SWAMP
SCALE 1:1000
Registration
Transactions
Authentication
Date
Records

78G27

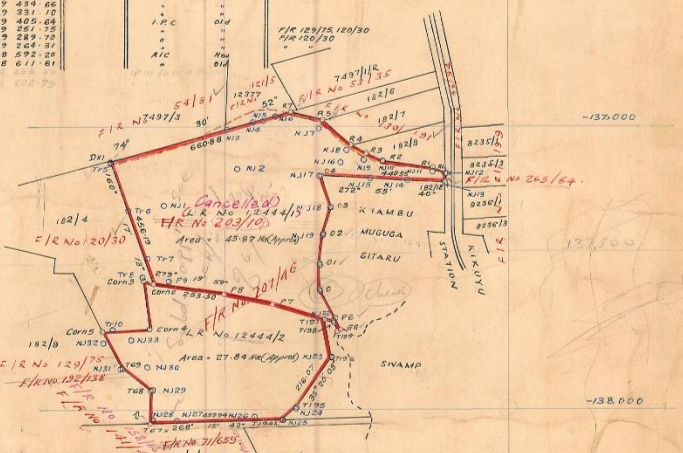
Co-ordinates Referred to...KRUAZ.B.R. 27/6/58

Units...METRES.....

Form No. 2

Station	— Y (Northings)	— X (Eastings)	Heights	Class of Beacon		
Tr8	137 533.62	39 294.27		I.P.C.U	Old	F/R 120/30
Tr9	137 710.26	39 265.67		"	"	"
Tr10	137 716.26	39 398.57		"	"	"
Tr7	137 465.62	39 272.75		"	"	"
Tr6	137 297.28	39 341.69		"	"	"
T5	137 127.88	39 414.12		"	"	"
NJ1	137 282.75	39 215.32		"	New	
NJ2	137 150.12	38 957.82		"	"	
NJ3	137 610.48	38 996.42		"	"	
NJ4	136 986.90	38 981.90		"	"	
NJ5	136 982.93	38 966.32		"	"	
NJ6	136 967.73	38 821.03		"	"	
NJ7	137 807.24	38 668.73		"	"	
NJ8	137 088.65	38 570.82		"	"	
NJ9	137 121.55	38 508.77		"	"	
NJ10	137 124.17	38 442.42		"	"	
NJ11	137 160.62	38 265.85		"	"	
NJ12	137 167.21	38 224.13		"	"	
NJ13	137 174.34	38 227.17		"	"	
NJ14	137 189.03	38 358.84		I.P.	"	Temporary
NJ15	137 182.54	38 489.40		"	"	"
NJ16	137 128.32	38 594.14		I.P.C.U	"	
NJ17	137 175.47	38 667.24		"	"	
NJ18	137 286.25	38 629.08		"	"	
NJ19	137 383.95	38 657.28		"	"	
NJ20	137 490.74	38 668.93		"	"	
NJ21	137 581.34	38 664.41		"	"	
NJ22	137 687.07	38 617.56		"	"	
NJ23	137 818.02	38 622.81		"	"	
NJ24	137 995.44	38 752.77		"	"	
NJ25	138 035.93	38 799.14		"	"	
NJ26	138 028.47	38 899.39		"	"	
NJ27	138 038.18	39 172.24		I.P.	"	Temporary
NJ28	138 034.02	39 259.13		I.P.C.U	"	
NJ29	137 929.54	39 256.66		"	"	
NJ30	137 849.48	39 277.11		"	"	
NJ31	137 858.97	39 371.36		"	"	
NJ32	137 761.99	39 434.66		"	"	
NJ33	137 752.86	39 331.10		"	"	
DK1	137 723.64	39 405.64		I.P.C	Old	
Corn2	137 633.70	39 251.75		"	"	F/R 129/75, 120/30
Corn3	137 545.97	39 289.70		"	"	F/R 120/30
Corn4	137 713.70	39 264.81		"	"	"
G8	137 717.17	38 592.26		A.I.C	New	
P6	137 678.80	38 611.61		"	Old	

Line	Bearing	Distance M.
R7 - R5	105° 41' 55"	119.33
R5 - R4	131 41 35	129.87
R3 - R4	301 19 30	62.89
R3 - R2	112 49 00	64.48
R2 - R1	97 27 10	176.14
R1 - RL	114 13 15	53.11
RL - 182/1E	181 11 10	31.39
04 - 03	161 53 20	115.67
03 - 02	196 02 40	99.61
02 - 01	186 07 20	105.16
01 - 0	179 17 05	89.82
0 - P6	153 10 20	114.03
P6 - G6	153 10 20	43.00
T199 - T198	337 46 18	31.91
T198 - T197	287 21 26	31.78
T197 - T196	170 58 47	131.81
T196 - T195	215 20 68	216.87
T195 - T194x	231 43 46	71.06
T68 - T67x	181 58 24	116.44
T69 - T68	127 50 47	128.42
Corn5 - T69	152 46 56	143.61
Corn5 - Corn4	85 49 00	165.95
Corn4 - Corn3	351 23 33	169.84
Corn3 - Corn2	100 38 41	38.61
T197 - P7	286 32 35	193.20
P7 - P8	281 40 45	173.09
G6 - T199	243 37 18	13.73



Stations	-Y Northings	-X Eastings	Class of Beacons		
RL	137 577.26	38 663.09	A.I.C.	Old	
01	137 587.26	38 664.22	"	"	
02	137 380.73	38 685.00	"	"	
03	137 287.84	38 625.42	"	"	
04	137 177.07	38 661.26	"	"	
182/1E	137 199.56	38 721.31	"	"	Missing
RL	137 168.19	38 226.66	"	"	
R1	137 146.43	38 269.09	"	"	F/R 129/75
R2	137 123.53	38 443.74	"	"	
R4	137 065.83	38 556.90	"	"	
R3	137 098.52	38 508.17	"	"	
R5	136 975.47	38 653.87	"	"	
R7	136 947.13	38 768.75	"	"	Missing
P7	137 829.25	38 832.10	I.P.C.	New	
P8	137 594.21	39 001.61	"	"	
P9	137 545.80	39 199.71	I.P.	Temporary	
Corn5	137 725.80	39 429.81	I.P.C.	Old	F/R 120/30 In a Fence Post.
T69	137 853.51	39 364.13	"	"	In the Fence Post Re-esc.
T68	137 932.30	39 262.72	"	"	" " " " "
T67x	138 048.67	39 266.71	"	New	In a fence Post.
T194x	138 034.72	38 806.98	"	New	
T195	137 990.70	38 781.21	"	Old	In a Fence Post.
T196	137 814.44	38 626.24	I.P.C.	Old	F/R 129/75 In a Fence Post.
T197	137 684.26	38 646.90	"	"	" "
T198	137 693.74	38 616.58	"	"	" "
T199	137 723.27	38 604.50	"	"	" "

I hereby certify that I, in person, made, and on the 8th day of October 19 70 completed the survey represented by this plan, on which are written the bearings and lengths of the lines surveyed by me, and that the survey has been executed in accordance with the existing regulations and with the approved scheme.

Letter No.....of.....

N. Mwaniki Mungai
Surveyor.

SCALE 1/10,000

E/2 Nos 129/75, 120/30, 54/81, 121/5, 130/199
F/R No 97/45

Plot/Parcel No. L.R. Nos 12444/1-2

Ref. Map/R.I.M. S.A. 37/G/1 & 2 (1961)

Sheet No.....

Registration District

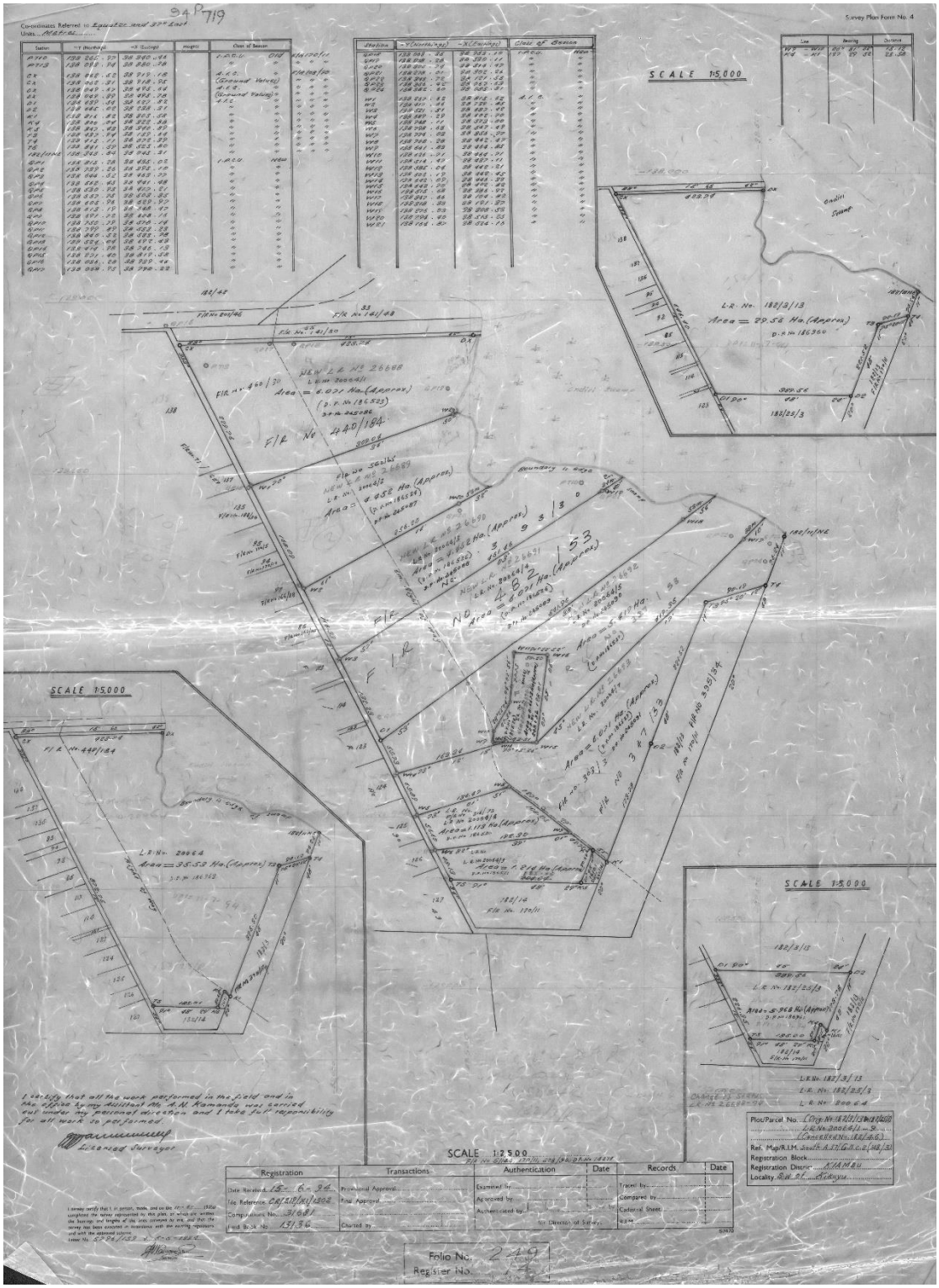
Section No. KIAMBU

Locality WEST OF KIKUYU

Registration	Transactions	Authentication	Date	Records	Date
Date Received 6-11-78	Provisional Approval	Examined by		Traced by	
File Reference CR/219/531	Final Approval CR/219/526A	Approved by L. K. Kabuka	13-11-87	Compared by	
Computations No. 17284		Authenticated by	29/11/87	Cadastral Sheet	
Field Book No. 10392	Charted by	for Chief Surveyor		R.I.M.	

PLAN DRAWN BY G.O. OBARA 1-11-78

Folio No. 146
Register No. 45


Survey Plan Form No. 4
SCALE 1:5000
SCALE 1:5000
SCALE 1:5000
SCALE 1:2500
I certify that all the work performed in the field and in the office by my Assistant Mr. A.M. Ramanda was carried out under my personal supervision and I take full responsibility for all work so performed.
Licensed Surveyor
Registration
Transactions
Authentication
Date
Records
Date
Folio No. 249
Register No. 4